Mariners Weather Log

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Marine Meteorological and Oceanographic Guidance Products from the National Centers for Environmental Prediction

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I. INTRODUCTION

NMC was reorganized as a part of the National Weather Service's (NWS) modernization and restructuring into what is now referred to as NCEP in 1995. NCEP is divided into nine centers: seven are forecast centers, one is a modeling center, and one is a computer operations center. Of the nine centers, three have marine meteorological and oceanographic responsibilities:

- The Marine Prediction Center (MPC)
- The Tropical Prediction Center (TPC) (formerly known as the National Hurricane Center)
- The Environmental Modeling Center (EMC) (specifically, the Ocean Modeling Branch [OMB])

The MPC and TPC provide forecasts to the marine community and guidance to coastal Warning and Forecast Offices (WFOs). The OMB creates and provides guidance to the MPC, the TPC, and WFOs. Many of these products are also available to the public on the Family of Services or Internet, the appropriate interpretation of these products always comes from the field office charged with a given marine responsibility. In this article, the responsibilities of the OMB are discussed. Also a brief list of the guidance products produced by the OMB is given. In addition, dissemination of the products is discussed. In future articles other aspects of the marine guidance products or forecast products produced by NCEP will be discussed.

II. RESPONSIBILITIES OF THE OMB

The primary responsibilities of the OMB are to:

- Prepare and disseminate operational marine guidance material to NOAA field forecast offices and the civil sector
- Develop improved numerical analysis techniques
- Develop state-of-the-art numerical forecast model output products
- Evaluate and improve the quality of the guidance products and develop new products to accommodate user needs
- Provide special support for the quality control of remotely sensed measurements of winds and waves

Because the primary function of OMB is to produce operational guidance products, the emphasis is on applied research and technology transfer whenever possible. For convenience the activities of the OMB are carried out in the following broad areas:

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On the Bridge

The Old Man's Chair

A Different Look at Bridge Team Management

J. Samuel Teel
Maine Maritime Academy

Years ago I was sailing off the board from the New York union hall. After a week or so I landed a berth as third mate aboard a SeaLand ship. She paid well and had a good itinerary that took her to northern Europe and Spain before returning to the United States. The bonus came when I learned who the captain was. I had sailed with him off and on for a number of years and had always enjoyed the trips with him. His ship always ran well, everybody got along, and things went smoothly.

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From the Editor

This issue of the Mariners Weather Log marks the second in what I hope will be a long and enjoyable relationship.

I have received many calls and letters from readers. Overall, the response to the changes we have been instituting has been very positive. One point that seems to come up in almost every piece of corespondence I've received so far is that the new format "seems to be missing the cover," and "where are all the great pictures?" The "newsletter style" format we are using commences with articles on the first page—as opposed to a magazine format which allows an introductory cover page. Also, if you send us pictures, we will use them. We can't afford to pay for them, and we would like to keep them if we get them (we are thinking of putting together a "scrapbook" of MWL pictures on CD-ROM, what do you think?).

I would like to start a "Letters to the Editor" department. That way, other readers would get a chance to see the kind of comments that are coming in, and maybe comment themselves. If I get enough letters, I'll start with the next issue. Remember, though, the deadline is October 15, so if you want to send me an uncomplementary letter, send it after that (just kidding!). As I said before, please keep those comments (positive and negative) coming. They will help both us and the "powers that be" tremendously in determining the future course of the Log.

As to this issue, I think you will find it as entertaining and informative as the last. Sam Teel's "On the Bridge" article teaches us both humility and humanity, not to mention respect. We also have an article from Dr. Gray of Colorado State University. Dr. Gray's column will now be a regular feature and we thank him for his generous contributions to the Log. The VOS Cooperative Ship Reports highlight some of those vessels that make the program work. And the articles on physical oceanography, biology, Great Lakes shipwrecks, and underwater archeology are as entertaining as they are informative.

On August 15, 1996, there will be a change of e-mail addresses for some government employees. We did not receive all of the new addresses in time for inclusion in this issue, but keep a lookout; they will be in the next issue for sure. Our e-mail address (wvrs@erols.com) will not be affected.

I'm sure you would like to get on to the *real* reading material, so I'll end for now. And as the skipper who taught me everything I know about boating said: "Keep the wet side down!" I wonder what I'm supposed to do when it rains…

John Oscanyan⚓

Products

Continued from Page 1

- Marine Meteorology
- Ocean Wave Dynamics and Modeling
- Coastal Ocean Forecasting
- Polar Seas and Great Lakes Ice Modeling
- The National Marine Verification Program (NMVP)

III. PRODUCT LISTS

The products are listed by development group within the OMB. A brief description of the NCEP models used to produce the products listed is presented. The list gives the product and the generating model if applicable. For more complete details, see Burroughs (1995).

A. Marine Meteorology

The NCEP runs three operational analysis and numerical weather prediction models which are available to provide marine information over the oceans twice a day at 0000 UTC and 1200 UTC. These models include: a global spectral forecast model; a regional analysis and forecast model (RAFS); and a newly implemented regional "ETA" model. Most marine applications have been made by using the aviation run (AVN) of the Global Spectral Atmospheric Model. Products include:

- Ocean surface winds (AVN)
- Coastal and Great Lakes Statistical Wind Forecasts (RAFS)
- Santa Ana Regime and Wind Forecasts (RAFS)
- Superstructure Ice Accretion (AVN)
- Open Ocean Sea Fog and Visibility (AVN)
- Satellite Ocean Surface Wind and Wave Products

B. Ocean Wave Dynamics and Modeling

During the last five decades, wind wave forecasts have improved significantly from the empirical approaches of the 1940s and '50s to the spectral approaches of today. The NCEP has continuously made a systematic effort to test and develop models based on sound wave dynamics, prediction accuracy, and computational efficiency and to employ them to produce operational forecasts. Currently, a deep water global model and two variable depth regional models (for the Gulf of Mexico and the Gulf of Alaska) are operational.

1. Global Spectral Wave Model

This is a third generation wave model called WAM (Chen, 1995) and incorporates the most updated dynamics in wave generation, dissipation, and nonlinear energy transfer processes. Products from this model include:

- Significant wave heights
- Mean propagation of the wave spectrum
- Mean period of the wave spectrum
- Matrices of spectral energy densities as a function of frequency and direction at selected locations

2. Regional Wave Models

Regional wave forecasting models are concerned with forecasting wave conditions over a limited area (less than global) which is characterized by unique environmental conditions (physiographic, meteorological, and oceanographic) such that a global scale wave model is unable to provide adequate wave information for that particular area. There are two regional models currently operational over the Gulf of Mexico and Gulf of Alaska.

a) Gulf of Mexico Regional Spectral Wave Model

This model is a second generation spectral wave model (Chao, 1991) applicable for both deep and shallow water areas of the Gulf of Mexico. It solves a spectral energy balance equation involving wave growth by winds, refraction by bottom bathymetry, energy loss due to whitecapping and bottom friction, as well as parameterized wave-wave energy transfer. The Gulf is assumed to be an enclosed basin.

Model outputs include:

- Significant wave heights
- Prevailing wave direction either of the wind-sea or the swell

b) Gulf of Alaska Regional Spectral Wave Model

The structure of the Gulf of Alaska model is essentially the same as Gulf of Mexico model; however, unlike the Gulf of Mexico which can be considered an enclosed basin, the Gulf of Alaska is open to the Pacific Ocean. Hence, the wave conditions inside the Gulf are determined by the wave trains propagating into the Gulf from the open ocean as well as the local winds over the Gulf. In this model, the waves propagating in from the Pacific across the mouth of the Gulf are obtained from the operational global wave model.

Products include:

- Significant wave height of combined sea and swell
- Period and direction associated with the peak energy of the directional spectrum
- Significant wave height, mean period and mean direction of the swell

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Products

Continued from Page 3

- Significant wave height and mean period of the wind-sea

C. Polar Seas and Great Lakes Sea Ice

Official ice analyses and forecasts are produced by the National Ice Center (NIC) by combined NOAA, U.S. Navy, and U.S. Coast Guard efforts. At this time the only product routinely produced and disseminated by NCEP is a set of drift sea ice vectors for the northern and southern hemisphere. The drift vectors are forecast out to seven days.

D. National Marine Verification Program

The objectives of the NMVP are to help:

- WFO forecasters identify strengths and weaknesses in forecast skill
- NCEP distinguish good and bad points in their guidance
- Program managers discriminate assets and liabilities in marine services

Observed data, WFO forecasts, and NCEP guidance data are merged together for specific verification times into a Marine Verification Matrix (MVM). The data in the matrix are used to evaluate forecasts of four forecast elements: wind direction, wind speed, significant wave height, and SCAs/wind warnings.

IV. EXPERIMENTAL AND DEVELOPMENTAL PRODUCTS

In addition to the operational products which run on a regular basis without interruption, except on extremely rare occasion, there are two additional classes of products: experimental and developmental. Experimental products are ready for general comment and public dissemination on the Internet. Developmental products are not ready for general comment or public dissemination. They are given limited distribution on the Internet. Experimental and developmental products are produced by the following projects:

- East Coast Regional Wave Model
- Coastal Ocean Forecast System - East Coast Region
- Polar and Great Lakes Ice Prediction Systems

V. PRODUCT DISSEMINATION

Operational products are sent out to field offices on various internal NWS communications circuits plus the Family of Services circuits to the public. Many are on the Internet as well.

Experimental and developmental products are available on the Internet only. Developmental products are available only to select evaluation groups on the Internet.

Most products are updated twice a day about 6-h after cycle time (0000 or 1200 UTC). Global products are available with projections out to 72-h, while regional products are available with projections out to 48-h. See Burroughs (1995) for full details.

Information about these products and many of the operational and experimental products are available for viewing on the Internet at the EMC or OMB home pages. The EMC home page is found at http://nic.fb4.noaa.gov:8000. The OMB home page is found at http://polar.wwb.noaa.gov/.

VI. SUMMARY AND FUTURE PLANS

The products listed here are not expected to be static and unchanging; rather, they will undergo periodic re-examination, in view of the latest technical advances, to determine their value to users and their validity. Plans for improving the existing material and developing new products are continually evolving and parallel the progress in the art of numerical weather and ocean prediction, improved analysis techniques, increased availability of data from future satellites, and the advent of advanced dissemination systems.

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The Old Man's Chair

Continued from Page 1

The mates and engineers worked together, even the crew seemed to be in a good mood. All of this could be attributed to the captain's attitudes and method for running the ship.

On the return leg to the States we would always have a cookout on the boat deck. Steaks, burgers, and grilled prawns. Cookouts were a major activity aboard the ship and preparation began early in the day. I was tasked with the creation of the punch. I took this job very seriously and researched it thoroughly all morning by questioning every member of the crew about suggested ingredients. The grill was fired up around 1630 and we gathered around telling our old sea stories. It was a perfect evening. Clear skies, gentle swell, porpoises on the bow, and the Azores up ahead in the distance. The punch was brought out and, while it looked rather poor, it tasted good and had the desired effect.

As I said before, this was a good ship and we all enjoyed working aboard her. The master's interest in his crew and his participation in the monthly homebound cookout was just all part of his way of managing the ship.

I had the eight to twelve watch and by 1800 I tipped back my last glass of punch. By 1900 I had headed back to my stateroom, showered, and got ready for watch. By 1945 I was on the bridge going over the charts and getting ready to relieve the second mate. I could smell the steaks and garlic drifting up from below. I could hear the music playing and the voices of the others still enjoying themselves. As you might suspect, the second was quick to be relieved and headed below to take my place.

I set about my routine, got an amplitude of the sun, plotted the satellite fix, did the synoptic weather, made coffee, drank coffee, and it still wasn't even 2100. The smoke from the grill continued drifting in and out of the wheel house. The helmsman and I complained about this and that. All the while I could hear the sizzle of steaks being laid on the fire. I recall thinking that if I had to be at sea, missing summer at home, then this was pretty good, at least compared to other ships I'd been on. Ships where nobody spoke to each other, where the lounge was never used, where the captain lived in his cabin only to come out and grumble.

As the bridge got darker, I found myself backed up against the captain's chair. Not sitting in it, just leaning against it. Within ten minutes I had managed to change my position to achieve the time honored, butt-cheek rest. Not really sitting, but not really standing either. In ten more minutes I had thrown caution to the wind and lifted myself up into a full support, foot rest position. This is one step short of complete use of the chair. As many young mates know, in this position you don't actually lean back or use the arm rests, it is more like sitting on a stool. I'm in the stool position and the helmsman pipes up and says something like, "You better watch out mate, the old man might catch you…." I told the helmsman not to worry about it. He chuckled and lit up a cigarette, momentarily illuminating the bridge. Such a relaxing evening, I thought to myself, and besides, the captain never sneaks up on the bridge. I know that he always comes into the chart room first, rustles around on the chart table, and then enters the wheel house. Besides that, I wasn't too worried about sitting in his chair. We'd go out to dinner in port, drink coffee in his office after watch, and play cribbage in the evening. As I was thinking about this, I slipped back into the "complete recline, feet up, arm resting, I deserve to sit here" position.

Again the helmsman jokingly reminded me that I could get in big trouble. "Yeah, yeah, don't worry about it," I said.

Then I heard the voice, the captain, standing in the starboard bridge wing door. "Mr. mate," long dramatic pause, which allowed me to melt out of the chair, "step out here on the wing."

Oh man, I thought to myself, stupid me, I had to sit in his chair, now he's worked up, now I get chewed out, my fault, stupid chair, at least he's going to give it to me out on the wing. Better than to stand here in front of the helmsman.

I walked out to the wind, feeling like a kid caught with his hand in the candy jar. The old man turned away and started walking aft around the back side of the house, saying, "We're going up on the fly bridge," in a not so warm tone of voice.

Boy, is he really upset about this, I thought to myself, he's so upset that he wants to be up on the house top before he tears into me. We climbed the ladder aft of the house and made our way forward across the deck. All the time I was thinking to myself that he must be really mad and I've got no one to blame but myself.

In the moonlight I could make out the shape of the binnacle and the vent intakes. Perched on top of one of the intakes was the punch bowl with two mugs beside it. The captain paused briefly by the bowl, grabbed a mug, scooped out a drink and handed it to me, saying something about how he thought I'd enjoy a little more before the night was over. Naturally, I hesitated, then said to him, "Captain, I'm

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The Old Man's Chair

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on watch." He replied by informing me that he knew who was on watch and furthermore he didn't think it was a problem. How about that, I thought to myself as I reached for the mug. So I wasn't caught after all, there is no problem, I got away with it.

There weren't any ships around us and the visibility was perfect. I went below long enough to let the helmsman know that I'd be up on the flying bridge and to just give me a tap on the overhead if he needed me. We stayed up there till midnight, talking about everything, the company, the ship, our families.

When it came time to call it a night, I shook his hand and turned to walk away. He let me get about ten feet across the desk and then called me. "Sam," he said, "by the way, don't ever sit down in my F#@*$&% chair again." The friendly tone was gone and his voice had that absolute command quality to it. He caught me completely off-guard. He wasn't smiling but he wasn't angry either, he was just stating the way it would be. He had me. I knew it and he knew it. He knew that I thought I had gotten away with it and he handled it perfectly.

I use this story as an illustration for the cadets at Maine Maritime when I'm talking about qualities of command and management. This captain had the ability to manage a situation. I use the term "reality management." I doubt that he consciously planned it out as to how he would handle the young third mate sitting in his chair. He did however realize that we had a certain amount of respect for each other and that chewing me out in the standard fashion would most likely be counterproductive. I was going to be on the bridge each morning and evening and the last thing he needed was a young mate with an attitude. He got his message across. It put me in my place. I worked harder, stood a more alert watch, and just generally had more respect for him. This gets to the core of bridge team management.

Most merchant officers don't have a management degree or a background in human relations. However, what we do have is a wealth of experience which is magnified by our living and working conditions. Our industry is unique. The nature of our work forces us into close quarters. Shore-based personnel may spend 40 to 60 hours together during a work week. Multiply that by a factor of four and add that we not only work together but we live and eat together as well. The positive side of this is that it provides us with a chance to get more experience in five years than many people get during an entire career.

Officers should observe what works and what doesn't. We should concentrate on the ships and situations that were memorable because either something good was taking place or something bad was happening. We can certainly learn from other people's mistakes.

Good people management can be a learned skill. One of the keys is to ensure that what you take away from a situation is a repeatable skill; something that may be used time after time. This is especially true when managing a ship's crew, particularly when dealing with subordinates. What stands out about the captain from my story is his consistency and focus. Consistency because there was never any uncertainty by the officers or crew on where he stood on any issue. He communicated clearly and concisely what his expectations were. His focus was a well-run ship. Virtually everything he did or said was directed at the safe and efficient operation of the vessel. Even the cookouts and his manner of dealing with the third mate in his chair.⚓

United States Government
INFORMATION

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National Prediction Center Reports

Marine Prediction Center

George Bancroft
Graphics prepared by Joe Sienkiewicz

High Seas Text Bulletins Issued by MPC

The MPC's Marine Forecast branch (MFB) has forecast responsibility for two areas:

1. The North Pacific between 30N and 50N east of 160E and the area east of a line from 50N 160E to the Bering Strait.

2. The North Atlantic between 32N and 65N west of 35W.

The North Pacific area of high seas responsibility covers a vast area of ocean with a longitudinal range twice that of the North Atlantic area of responsibility and considerably more ocean area north of 40N, resulting in a forecast area more than twice that of the North Atlantic.

MPC/MFB issues the following high seas text bulletins every six hours with issuance times (UTC) given:

North Pacific 0500, 1100, 1700, 2300
North Atlantic 0430, 1030, 1630, 2230

The initial Pacific issuance is actually released about 45 minutes earlier than the issuance time in the heading in order to meet broadcast deadlines.

Preparation and Transmission

The high seas bulletins are prepared after forecasters have examined output from about seven numerical models including up to three ocean wave models. The Tropical Prediction Center's (TPC) Tropical Analysis and Forecast Branch prepares a tropical high seas forecast for each ocean, south of 32N for the Atlantic and south of 32N for the Pacific. The MFB forecasters then append TPC's tropical portion to the respective Pacific and Atlantic forecasts. The bulletins are then transmitted to the NWS computer/communications system and via the NOAA Weather Wire Service (NWWS) to the USCG and various commercial radio stations which rebroadcast it to ships at sea. An additional North Pacific bulletin is prepared and transmitted every six hours about an hour after the initial bulletin is transmitted by appending the Honolulu high seas forecast which covers an area from the equator to 30N between 160E and 140W. The Atlantic bulletin and the aforementioned second issuance of the North Pacific bulletin include an extra line of number and letter codes enclosed by the word "CCODE," described below, which is a form of routing code required for sending the bulletin via Inmarsat satellite to ships at sea through COMSAT's GMDSS (Global Maritime Distress and Safety System) SafetyNET service. This is in addition to the routing to NWWS. In order to receive SafetyNET transmissions, a ship at sea must have a proper Inmarsat EGC SafetyNET receiver on board initiated to receive information for the proper area covered by the bulletin.

Two examples of text forecasts are shown on page 8. Below the communications heading at the top, the CCODE line contains five number groups and two letter code groups. Also, below the heading containing the high seas forecast issuance time, there is an international communications descriptor term (SECURITE or PAN PAN) which immediately precedes the forecast area heading. The first number group, a 1 or 2, is the priority or urgency code. It is usually a "1" which is used with the "SECURITE" descriptor, but if the forecast contains hurricane force winds associated with a tropical cyclone it becomes a "2" which is used with the "PAN PAN" descriptor and triggers an audible alarm at the receiver aboard ship. PAN PAN is also used for extratropical hurricane force winds but in conjunction with "1" in the CCODE and no alarm is generated. The second number code is a two digit service code which is 31 for meteorological and navigation warnings. The third number code denotes GMDSS area to which the message pertains (12 for the northeast Pacific and 04 for the northwest Atlantic used in MPC's bulletins). The fourth code is a repetition code, normally "01" for routine scheduled broadcasts but is changed to an "11" for unscheduled transmissions, causing the broadcast to be repeated 6 minutes after the initial broadcast. The fifth number code is a presentation code or alphabet (always "00"). Letter codes follow the number codes after the "/." The first, AOW in the North Atlantic bulletin and AOW+POR in the Pacific bulletin, denotes the satellite over which the product is to be broadcast. "AOW" refers to the Atlantic Inmarsat satellite and "POR" is the Pacific satellite. The second letter code is the originator code (in this case NWS).

Format and Content

High seas forecasts have primary focus on major weather systems and sea states affecting ocean going vessels. The forecasts are valid for the 36 hour period from an initial time which is the 6 hourly synoptic analysis time preceding the issuance time. An exception is for tropical cyclones which use the time of the latest advisory. The warning section of the

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ZCZC NFDHSFEPI
TTAA00 KNFD 281126

CCODE/1:31:12:01:00/AOW+POR/NWS/CCODE
HIGH SEAS FORECAST
NATIONAL WEATHER SERVICE WASHINGTON DC/TPC MIAMI FL
MARINE PREDICTION CENTER/MFB 1100 UTC 28 JUN 1996
SUPERSEDED BY NEXT ISSUANCE IN 6 HOURS

SECURITE
PACIFIC N OF 30N AND E OF A LINE FROM THE BERING STRAIT TO 160E.
SYNOPSIS VALID 0600 UTC 28 JUN. FORECAST VALID 1800 UTC 29 JUN.

WARNINGS

DEVELOPING GALE 43N 168W 1004 MB MOVING NE 35 KT. WINDS 20 TO 30 KT SEAS 08 TO 13 FT WITHIN 420 OVER SE QUADRANT AND 240 NM OVER NE QUADRANT. BY 281800 UTC GALE 45N 159W 1003 MB WITH WINDS 25 TO 35 KT 9EAS 08 TO 15 FT 420 NM OVER S AND SE QUADRANTS. FORECAST GALE 51N 136W 1002 MB. FORECAST WINDS 25 TO 40 KT SEAS 12 TO 20 FT WITHIN 480 NM SE SEMICIRCLE.

SYNOPSIS AND FORECAST

LOW 40N 168E 997 MB MOVING ENE 35 KT. WINDS 20 TO 30 KT SEAS 08 TO 12 FT WITHIN 300 NM OVER N SEMICIRCLE. FORECAST LOW 43N 162W 1009 MB. FORECAST WINDS 20 TO 30 KT SEAS 08 TO 14 FT WITHIN 420 NM S AND SE QUADRANTS AND 300 NM OVER N SEMICIRCLE.

LOW 59N 156W 996 MB DISSIPATING IN 24 HOURS. WINDS 20 TO 30 KT SEAS 08 TO 14 FT BETWEEN 50N AND 55N FROM 138W AND 170W. FORECAST LOW AND CONDITIONS DISSIPATED.

FORECAST LOW 42N 170W 1010 MB. FORECAST WINDS 20 TO 30 KT SEAS 08 TO 12 FT WITHIN 240 NM OVER NW QUADRANT.

FORECAST AREA N WINDS 20 TO 30 KT SEAS 08 TO 13 FT BETWEEN 36N AND 40N E OF 129W.

AREAS OF DENSE FOG LOWERING VISIBILITY BELOW 1 NM N 40N AND W OF 165W. FORECAST CONDITIONS TO CONTINUE.

HIGH 36N 151W 1027 MB NEARLY STATIONARY FIRST 24 HOURS THEN MOVING ENE 20 KT. FORECAST HIGH 38N 142W 1031 MB.

HIGH 54N 179W 1018 MB MOVING ESE 05 KT. FORECAST HIGH 52N 175W 1025 MB.

ERS/MARINE FORECAST BRANCH
HIGH SEAS FORECAST
TROPICAL ANALYSIS AND FORECAST BRANCH
TROPICAL PREDICTION CENTER MIAMI FL
1030 UTC FRI JUN 28 1996

EPAC N OF EQUATOR TO 30N E OF 140W.

SYNOPSIS VALID 0600 UTC FRI JUN 28.
FORECAST VALID 1800 UTC SAT JUN 29.
...
WARNINGS.
NONE.
...
SYNOPSIS AND FORECAST
NORTH PAC PRES RIDGE 20N 120W 30N 125W BUILDING THROUGH PERIOD.
AREA OF WINDS FROM 20N TO 30N FROM 108W TO 118W
WIND NW 20 KT SEAS 5 TO 8 FTINCREASE TO 25 KT 7 TO 10 FT
BY 1800 UTC JUN 28THEN LITTLE CHANGE.
.
TROPICAL DISTURBANCE 13.5N 97.5W MOVING TO THE WEST 10 KT.
FORECAST DISTURBANCE 13.5N 103.0W.
REMAINDER WIND LESS THAN 25 KT SEAS LESS THAN 8 FT.
...
...CONVECTION VALID AS OF 0900 UTC FRI JUN 28. . .
WITHIN 270 NM RADIUS OF DISTURBANCE.. NUMEROUS CONVECTION.
.
INTERTROPICAL CONVERGENCE ZONE. . 10N 79W 13N 98W 7N 140W.
EXCEPT AS NOTED WITH DISTURBANCE. . NO SIGNIFICANT CONVECTION.
JT

NORTH PACIFIC EQUATOR TO 30N BETWEEN 140W AND 160E.
SYNOPSIS 0600 UTC JUN 28 AND FORECAST VALID 1800 UTC JUN 29 1996

WARNINGS. NONE.

SIGNIFICANT WEATHER FEATURES AND FORECAST.

TROUGH THRU 06N 170W 09N 140W NEARLY STATIONARY. ISOLATED MODERATE TSTMS WITHIN 60 NM OF TROUGH.

RIDGE THRU 30N 163W 22N 180 17N 160E NEARLY STATIONARY.

ISOLATED MODERATE TSTMS WITHIN AREA BETWEEN 02N AND 14N BOUNDED BY

ZCZC NFDHSFAT1 ES
TTAA00 KNFD DDHHHH

CCODE/2:31:04:01:00/AOW/NWS/CCODE
HIGH SEAS FORECAST
NATIONAL WEATHER SERVICE WASHINGTON DC/TPC MIAMI FL
MARINE PREDICTION CENTER/MFB 2230 UTC JUL 9 1996
SUPERSEDED BY NEXT ISSUANCE IN 6 HOURS

PAN PAN
NORTH ATLANTIC NORTH OF 32N TO 65N AND WEST OF 35W.
SYNOPSIS VALID 1800 UTC JUL 9. FORECAST VALID 0600 UTC JUL 11.

WARNINGS.

DEVELOPING GALE 47N 67W 998 MB MOVING NE 15 KT. WINDS 20 TO 30 KT AND SEAS 7 TO 11 FT WITHIN 540 NM SE SEMICIRCLE. FORECAST GALE 52N 60W 994 MB WITH WINDS 25 TO 35 KT SEAS 9 TO 15 FT WITHIN 540 NM SE SEMICIRCLE.

SYNOPSIS AND FORECAST.

IN ASSOCIATION WITH LOW E OF AREA...AREA W TO NW WINDS TO 25 KT SEAS 8 TO 13 FT N OF 55N E OF 40W. FORECAST CONDITIONS TO CONTINUE.

LOW 41N 49W 1010 MB MOVING NNE 10 KT AND DISSIPATE. WINDS 20 TO 30 KT SEAS 8 TO 14 FT WITHIN 540 NM E AND SE QUADRANTS. FORECAST LOW DISSIPATED.

AREAS OF LOCALLY DENSE FOG REDUCING VISIBILITY TO LESS THAN 1 NM OVER FORECAST WATERS N OF 41N AND W OF 40W. FORECAST CONDITIONS TO CONTINUE.

HIGH 49N 48W 1022 MB WILL MOVE ENE 20 KT AND DISSIPATE. FORECAST HIGH DISSIPATED.

FORECAST HIGH 39N 34W 1037 MB WITH RIDGE WSW TO 32N 64W.

JLC/MARINE FORECAST BRANCH
2230 UTC TUE JUL 09 1996

N ATLANTIC N OF 3N TO 32N W OF 35W INCLUDING THE CARIBBEAN SEA AND GULF OF MEXICO

SYNOPSIS VALID 1800 UTC TUE JUL 09.
FORECAST VALID 0600 UTC THU JUL 11.

WARNINGS
HURRICANE BERTHA 23.ON 71.6W AT 2100 UTC JUL 09 MOVING NW 15 KT.
MAXIMUM WIND 100 KT GUSTS 120 KT. RADIUS TROPICAL STORM FORCE WIND SEAS 12 FT OR GREATER 200 NM OVER NE QUADRANT 125 NM SW QUADRANT AND
150 NM ELSEWHERE. FORECAST HURRICANE 28.5N 77.0W AT 0600 UTC JUL 11.
MAXIMUM WIND 100 KT GUSTS 120 KT. RADIUS TROPICAL STORM FORCE WIND SEAS 12 FT OR GREATER 200 NM OVER NE QUADRANT 125 NM SW QUADRANT AND
150 NM ELSEWHERE. REQUEST 3 HOURLY SHIP REPORTS WITHIN 300 NM OF BERTHA. SEE LATEST ADVISORY.

SYNOPSIS AND FORECAST
ATLC EXCEPT AS NOTED IN WARNINGS WITHIN 400 NM OF BERTHA OVER NE QUADRANT WIND E 20 TO 33 KT SEAS 12 TO 20 FT THROUGH 0600 UTC JUL 11. ATLC ELSEWHERE EXCEPT AS NOTED IN WARNINGS ELSEWHERE WITHIN 300
NM OF OF BERTHA WIND 20 TO 33 KT SEAS 8 TO 12 FT THROUGH 0600 UTC JUL 11.

ATLC RIDGE 32N40W 30N60W 27N75W AT 1800 UTC JUL 09. FORECAST RIDGE ALONG 32N E OF 70W BY 0600 UTC JUL 11.

ATLC ELSEWHERE BETWEEN 10N AND 25N E OF 60W WIND E 15 TO 20 KT SEAS TO 9 FT IN E SWELL. FORECAST LITTLE CHANGE THROUGH 0600 UTC JUL 11.

ATLC N OF 30N W OF 70W WIND SW 20 KT SEAS 8 TO 10 FT. WINDS AND SEAS DIMINISHING BY 1200 UTC JUL 10. FORECAST WINDS AND SEAS INCREASING WITH APPROACH OF BERTHA..SEE ABOVE FORECASTS.

REMAINDER ATLC WIND LESS THAN 20 KT SEAS LESS THAN 8 FT THROUGH 0600 UTC JUL 11.

CARIBBEAN EXCEPT AS NOTED ABOVE E OF 70W WIND SE TO E 15 TO 20 KT SEAS TO 9 FT IN NE SWELL. FORECAST AFTER 1800 UTC JUL 10 WIND E 15 TO 20 KT SEAS TO 8 FT THROUGH 0600 UTC JUL 11.

REMAINDER CARIBBEAN WIND LESS THAN 20 KT SEAS LESS THAN 8 FT THROUGH
0600 UTC JUL 11.

GULF OF MEXICO WIND LESS THAN 20 KT SEAS LESS THAN 8 FT THROUGH 06G0 UTC JUL 11.

Marine Prediction Center

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text bulletin contains individual paragraphs for each warning area in descending order of importance relative to system strength (extent of storm or gale winds) or proximity to shipping routes. Tropical cyclones are mentioned first and are based on the latest advisory issued. Each paragraph gives the analysis location of the system in latitude/longitude coordinates; direction, speed, and trend of movement and/or intensity; and forecast intensity, pressure, and location. An intermediate location and intensity may be given for rapidly changing conditions such as rapid intensification. All times of changes are given as date and time (UTC) rather than day of week. Current and forecast wind speeds and combined seas (significant wave height) are given with either one representative value or a range (10 kt or ft) for the affected area in terms of distance from the pressure center, front, or trough; or by latitude and longitude; or as quadrants or semicircles around a center. Significant weather such as icing, squalls, and widespread heavy precipitation or fog may also be given.

The second part of the text forecast (synopsis and forecast) covers other map features (lows, highs, and ridges) and nonwarning conditions in the forecast including winds 25 kt or more and seas 8 ft or higher, and follows a paragraph format similar to the warnings.

Types of Warnings Issued by MPC

The Marine Prediction Center's text forecasts contain warnings of four main types which go into the WARNINGS section of the bulletin: gale warnings (winds 34 to 47 kt); storm warnings (winds 48 kt or higher); tropical cyclone warnings which include tropical depressions (maximum sustained winds 33 kt or less), tropical storms (maximum sustained winds 34 to 63 kt) and hurricanes (maximum sustained winds 64 kt or higher); and warnings for gale or storm force winds along the North Wall of the Gulf Stream. The storm warning category has a subcategory for extratropical hurricane force winds issued with the "PAN PAN" descriptor discussed above. Tropical cyclone warnings are issued in conjunction with the advisories and guidance of the various national tropical cyclone warning centers such as TPC (Atlantic basin including the Caribbean and Gulf of Mexico, and the eastern Pacific), the Central Pacific Hurricane Center in Honolulu (central Pacific between 140W and 160E, and the Joint Typhoon Warning Center in Guam (covering the area west of 160E). In coordination with the appropriate warning centers, MPC will place a tropical cyclone warning in its area of responsibility when the cyclone center moves into MPC's area. North Wall warnings are commonly issued during cold air outbreaks over the Gulf Stream in winter or early spring when wind and sea conditions may be substantially higher along the Gulf Stream than the prevailing conditions outside it and can be hazardous to even larger oceangoing vessels. A summary of the various types of warnings issued by MFB in 1995 follows.

MFB Warnings Issued in 1995

In early 1995 MFB started compiling monthly text warning summaries for both high seas forecast areas for which MFB is responsible. These depicted the numbers of warnings issued in each ocean area for the following warning categories:

- Gale Warnings
- Storm Warnings
- Storm>63 kt (for hurricane force winds associated with extratropical cyclones)
- North Wall Warnings (North Atlantic's Gulf Stream) Tropical Cyclone

A warning was counted in the statistics if it appeared as a paragraph in the warnings section of MFB's portion of a text bulletin. A tropical cyclone is counted if it appears in MFB's warnings section or if a reference is made to it when the center is south of MFB's waters and the cyclone is expected to affect MFB's forecast area of responsibility during the forecast period. A North Wall warning is counted if the higher wind and sea conditions along the Gulf Stream are stated in conjunction with a larger scale synoptic scale low pressure system or warning or appear as a separate paragraph (as is usually the case).

The results for 1995 are summarized in the following two figures and table (see pages 10 and 11). It should be noted that information for March 1995 is incomplete, and March statistics are not shown on the graphs. However, some March data is tabulated below in the results for the monthly average number of warnings in each category per text forecast and monthly average total warnings. In the graphical presentation of the results the top line denotes the total number of warnings issued each month for each high seas area and the lines below it represent the contributions of each warning type to the total. As an example, for the North Atlantic in January 1995 there were 370 gale warnings, 149 storm warnings, 10 storm warnings for winds >63 kt, and 18 North Wall warnings which contribute to the 547 total warnings on the top line of the North Atlantic graph.

Continued on Page 11

Average Number of Warnings Per Text Bulletin - 1995

(Issued by Marine Prediction Center Forecast Branch)

Gale Warnings

	North Pacific	North Atlantic
JAN	3.23	2.98
FEB	4.16	2.05
MAR	M	2.40
APR	2.63	1.93
MAY	2.34	1.74
JUN	2.20	1.42
JUL	1.06	1.21
AUG	1.36	1.77
SEP	2.21	1.63
OCT	2.27	1.92
NOV	3.30	2.34
DEC	4.27	1.67

Tropical Cyclone Warnings

	North Pacific	North Atlantic
JAN-JUN	NO WARNINGS	
JUL	0	.23
AUG	.03	.46
SEP	.10	.28
OCT	0	.27
NOV	.02	.04
DEC	0	0

Storm Warnings

	North Pacific	North Atlantic
JAN	1.94	1.28
FEB	1.11	1.92
MAR	M	*1.13
APR	.71	.68
MAY	.25	.32
JUN	.23	.16
JUL	0	.03
AUG	.01	.07
SEP	.59	.45
OCT	1.18	.45
NOV	1.40	.86
DEC	1.88	1.48

Total Warnings

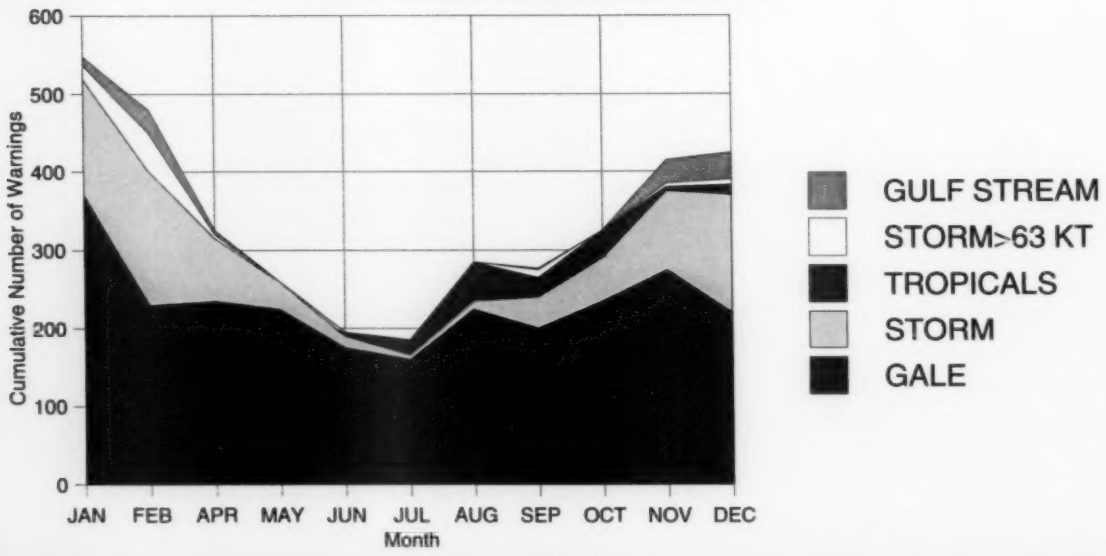
	North Pacific	North Atlantic
JAN	5.16	4.27
FEB	5.27	3.97
MAR	M	*3.79
APR	3.34	2.64
MAY	2.59	2.06
JUN	2.43	1.59
JUL	1.06	1.47
AUG	1.40	2.30
SEP	2.90	2.37
OCT	3.45	2.64
NOV	4.72	3.41
DEC	6.15	3.42

M = Missing

* Does not include storm warnings for winds greater than 63 kt (hurricane force).

NORTH ATLANTIC WARNINGS - 1995

MPC - Marine Forecast Branch



Marine Prediction Center

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Warning Results for 1995

Referring to the two graphical figures and table shown on page 10 and below, seasonal patterns are apparent in the warnings for both oceans. Gale and ordinary storm warnings peaked in December or January in both oceans, with the peaks more pronounced in the Pacific. Warnings for storm>63 kt were more erratic especially in the Atlantic where the peak of 50 in February is more than was counted in the remainder of the year combined (not including the missing March data) and also almost as much as the combined total of 11 months in the Pacific. A smaller peak for such warnings occurred in September in the Atlantic, some of which resulted from hurricanes becoming extratropical. The peak for Gulf Stream North Wall warnings came in February (usual late winter maximum). The minimum for extratropical warnings of all types was generally in early to mid-summer. In the Pacific, July produced no storm warnings at all, and only one minimal storm occurred in August. The Atlantic had no warnings for intense storm>63 kt in July and August. For both oceans, gale warnings contributed to a much greater percentage of the warning total in early summer, with its lack of storms and tropical cyclone activity.

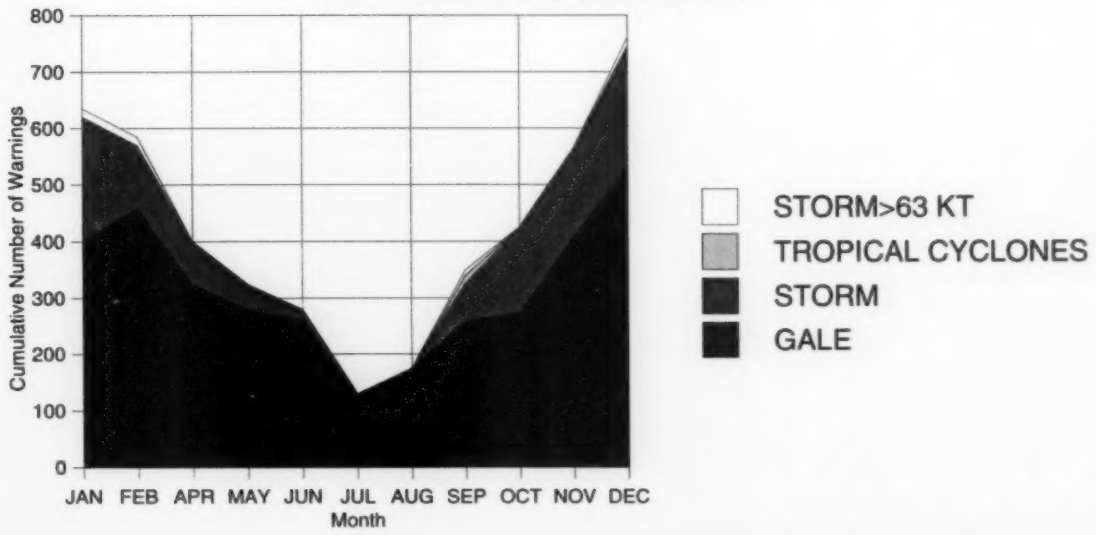
The 1995 Atlantic hurricane season was the second busiest on record, and contributed to a total of 157 tropical cyclone warnings in our high seas area of which 57, the peak, occurred in August. However, this amounted to only a little less than 0.5 warnings per forecast as shown in the tabulated results for average numbers of warnings per text forecast. The Pacific was much less busy with a total of only 18 tropical cyclone warnings for the year, of which 12 occurred in September. These were for western Pacific tropical cyclones recurving and entering the southwest portion of our marine area, with the central and eastern tropical Pacific not contributing any.

It is interesting to note the differences in numbers of extratropical warnings between the Atlantic and Pacific MFB areas of responsibility. The numbers of warnings in the Pacific were not that much greater than in the Atlantic, considering that the Pacific high seas area is more than twice the size of the Atlantic area. December stands out as a very busy month in the Pacific, the only month in which there were more than 500 gale warnings and more than 700 total warnings in either ocean. The December gale count was more than twice the number for the Atlantic, and the contrast was almost as great between the total warning counts. However, the other months showed less of a contrast, and in some of the months the Atlantic had more gale and/or storm warnings than the Pacific, especially in summer. The

Continued on Page 12

NORTH PACIFIC WARNINGS - 1995

MPC - Marine Forecast Branch



Mean Circulation Highlights and Climate Anomalies

Second Quarter 1996

A. James Wagner

The maps on page 13 of average 500-mb height and height anomalies (left) and average sea level pressure (SLP) and anomalies (right) readily show the principal long-lasting circulation features and their anomalies that affected the climate over the Northern Hemisphere during the second three months (Apr-May-Jun) of 1996. Only weak remnants of the blocking (above normal middle-tropospheric heights and accompanying SLP anomalies) that had been so prominent at high latitudes of the Atlantic and Eurasian sectors during the first three months of the year remained during the second quarter, with the main contribution coming from April over the Atlantic and over the Arctic and Bering Sea areas in May, and to a lesser extent, June. The mean high latitude circulation anomaly pattern completely reversed from April to June, as a large area of positive height anomaly was replaced by strong negative height anomalies over most of the Arctic. Statistical evidence from many past years indicates that such a reversal is most likely to occur between April and May, with the strongest tendency to change over the North Atlantic.

Negative anomalies existed over both major oceans at middle-low latitudes in both fields to the south, most notably over the central Atlantic and essentially all the way across the Pacific, where the jet stream was unusually strong, especially during April, and was associated with a continuation of more winter-like storminess in many areas. The jet stream acts as a steering current for the mobile cyclones and anticyclones that produce the day-by-day weather.

Over North America each month had rather different circulation and climate anomalies. During April, a mean trough continued over the eastern and central portions of the country while the anomalously strong ridge persisted over the Southwest, resulting in below normal temperatures over the eastern half of the country and developing heat and drought over the Southwest. The May circulation pattern was rather zonal across the Pacific and North America at middle latitudes, resulting in a zonal temperature contrast of below normal temperatures over the northern half of the United States and record early heat at times to the south, with daily temperatures rising over 100 degrees at several locations in the southern Great Plains and Southwest. Because the May anomaly pattern was the strongest of the three months, it is weakly reflected in both the average height and temperature anomaly patterns for the three-month season. Storminess and precipitation, excessive at times, was concentrated near the zone of temperature contrast while extreme northern and much of the southern sections of the nation were dry. The combination of heat and drought aggravated many wildfires in the Southwest from southern California to Texas. The biggest change came in June when most of the cold air (both in an absolute and in an anomalous sense) disappeared and monthly temperatures averaged significantly above normal over the Northeast for the first time since October 1995. Heat, drought, and resultant wildfires continued over the Southwest.

Over the European sector, some milder spring weather developed over northern and western sections, while relatively cold and stormy conditions continued over the Mediterranean and southeastern areas. April saw Spring arrive over eastern and southern sections, but colder and wetter weather returned to the British Isles and Scandinavia. Pleasant spring-like conditions prevailed in most areas during much of May.

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Marine Prediction Center

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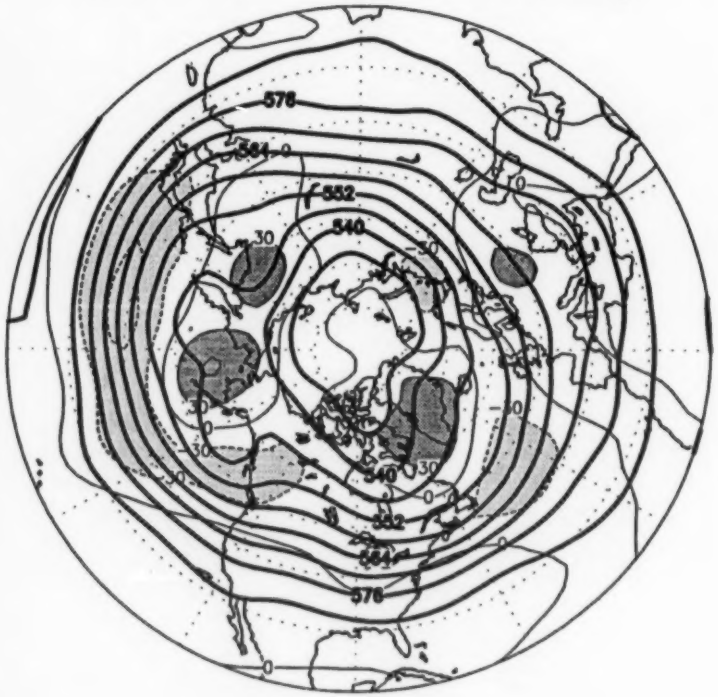
Atlantic had more total warnings than the Pacific in July and August. The Atlantic had considerably more intense storm activity than the Pacific in 1995 to the extent that we issued more warnings for extratropical hurricane force winds. Not counting, of course, the missing March data, there were 94 warnings for storm>63 kt in the Atlantic versus only 54 in the Pacific. The impressive February figure in the Atlantic for such warnings was already mentioned. The difference in the number of tropical cyclone warnings was noted in the preceding paragraph. Although the western Pacific produced more tropical cyclones than the Atlantic, fewer storms actually entered the Pacific high seas area; and when they did, they were moving rapidly into colder water and quickly becoming extratropical.

In terms of average numbers of warnings, average total warnings typically varied from 1 to 2.5 in summer for both oceans to between 3.5 and 4.5 warnings per forecast for the Atlantic and 4.5 to 5.5 in the Pacific in winter. The maximum average was 6.15 warnings in busy December in the Pacific. Average storm warnings ranged from less than 0.25 in summer to 1.5 to 2 in winter for both high seas areas (including both storm categories).⚓

April–June 1996

500 mb Height, Anomaly



The chart on the left shows the seasonal mean 500-mb height contours at 60 m intervals in solid lines, with alternate contours labeled in decameters (dm). Height anomalies are contoured in dashed lines at 30 m intervals. Areas where the mean height anomaly was greater than 30 m above normal have heavy shading, and areas where the mean height anomaly was more than 30 m below normal have light shading.

Sea Level Pressure, Anomaly

The chart on the right shows the seasonal mean sea level pressure at 4 mb intervals in solid lines, labeled in mb. Anomalies of SLP are contoured in dashed lines and labeled at 2 mb intervals, with heavy shading in areas greater than 2 mb above normal, and light shading in areas more than 2 mb below normal.

Tropical Highlights - June 1996

Gerry Bell
Climate Prediction Center
Washington, DC

Near-normal sea surface temperatures prevailed throughout most of the tropical Pacific during June 1995, indicating a further weakening of the 1995/96 cold episode. Below-normal sea surface temperatures (SST) were mainly confined to the far eastern equatorial Pacific. In the eastern tropical Atlantic, SSTs increased to more than 2.0°C above normal during June. Positive anomalies have increased in this region since March.

The low-level (850-hPa) equatorial easterlies were again stronger than normal across the central and western Pacific, with easterly anomalies greater than 3 m s^{-1} observed west of the date line. Enhanced easterlies have dominated the western half of the tropical Pacific since early 1995. However, there has been a gradual weakening of these anomalies east of 170°W since March 1996.

Convection [as inferred from outgoing longwave radiation (OLR)] was again weaker than normal over the central equatorial Pacific. Suppressed convection has been observed in this region since June 1995. However, the magnitude of the positive OLR anomalies has decreased since reaching a peak in January 1996. Farther west, convection over the Indian Ocean was enhanced during June, which is a reversal from the suppressed convection observed during May 1996.

During June, the depth of the equatorial oceanic thermocline remained greater than normal in the western and central Pacific and shallower than normal from 120°W to the South American coast. However, the depth of the thermocline in the east-central Pacific (between 160°W and 120°W) has increased over the past few months. Accompanying this structure, sub-surface temperatures at thermocline depth have averaged 2-4°C below normal between 120°W and the South American coast, and more than 1.0°C above normal west of 145°W.

The Southern Oscillation Index was 0.9 during June 1996, as the sea level pressure anomalies were well-above normal at Tahiti (1.5) and near normal at Darwin (0.1). However, the positive anomalies at Tahiti partly reflected an equatorward extension of a strong extratropical ridge.

Discussion and Outlook

Oceanic indices indicate near-normal conditions in the central and western tropical Pacific and cooler-than-normal conditions in the eastern tropical Pacific. Since February 1996 SST anomalies have increased throughout the equatorial Pacific as negative anomalies of about -1°C have gradually diminished in magnitude to near zero. Both surface and subsurface temperature anomalies in June reflected this return to near-normal conditions.

Statistical and coupled model predictions are consistent in indicating continued cooler-than-normal SSTs in the central and eastern equatorial Pacific during the remainder of 1996. Except for the CMP9 version of the NCEP coupled model, these forecasts indicate a strengthening of the negative SST anomalies during the next three months. Thereafter, the forecasts diverge with the linear inverse modeling technique indicating a return to near-normal conditions and the CCA indicating the development of warmer than normal conditions during early 1997.

The CMP9 version of the NCEP coupled model predicts near-normal conditions for the remainder of 1996, while the CMP10 version indicates a continuation of colder-than-normal conditions through early 1997. The Cane and Zebiak model and the LDEO2 model indicate a continuation of the colder-than-normal conditions through early 1997.⚓

Mean Circulation Highlights and Climate Anomalies

Continued from Page 12

Below-normal sea-surface temperatures continued over the equatorial Pacific throughout the three months, with a slight weakening toward the end of the period.

A tendency towards warmth and dryness across the southern portion of the U.S. is often seen during the cold phase of the El Niño - Southern Oscillation (ENSO) cycle.

The author is the Senior Forecaster in the Prediction Branch of the Climate Prediction Center/NCEP/NWS/NOAA. He participates in the preparation of all the types of forecasts done in the Branch: 6-10 Day Extended Outlooks, ½-month lead Monthly Outlooks, and the series of long-lead Seasonal Outlooks going out to a year ahead. Other duties of Mr. Wagner include applied research in developing tools for the various types of forecasts and giving special briefings on the forecasts and their methodology to the media and visiting scientists.⚓

Colorado State Professor Predicts About-Average Hurricane Year; '96 to be Up from Recent Inactive Period, Down from Record '95 Season

For the second consecutive year, coastal dwellers will have to keep an eye out for above-average numbers of tropical storms and hurricanes—but there will be much less storm activity than last year, Colorado State University's noted hurricane forecaster said in a report released on June 6.

William Gray, a professor of atmospheric science at Colorado State, predicts the hurricane season that began June 1 will see 10 tropical storms, just above the average of 9.3 tropical storms per season. From those tropical storms, Gray and his research team predict 6 hurricanes will evolve, a level just above the average of 5.8 hurricanes per season. Gray also predicts two intense storms, or Andrew-type hurricanes, will form. This is just under the average of 2.3 major hurricanes per season.

This forecast is a slight reduction from the April prediction but increases the overall storm activity forecast in November, Gray's first look ahead at the hurricane season.

In the update, Gray's research team predicts the 1996 season will have a Net Tropical Cyclone Activity level of 95 percent of normal. Net Tropical Cyclone Activity is a measure of all tropical storm, hurricane, and intense hurricane activity rolled into one number. The Net Tropical Cyclone Activity level in 1995 was 229 percent of the average season.

"We're forecasting a season with about average activity. That means we'll see a year that is much more active than the four recent inactive years of 1991-1994, but still considerably less storm and hurricane formation than last year—one of the most active seasons ever," Gray said.

"Last year, we were lucky. It was a very active season, but the number of landfalling storms was not as high as it could have been. This year will be less active, but there's no way to tell if we'll see more landfalling storms."

Gray said very active hurricane seasons statistically are usually followed by years with below-average activity. He said it is therefore significant that this season is shaping up to be about average in tropical storm and hurricane formation in comparison to the average over the last 45 years.

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	6/96	4/96	11/95
Named Storms (9.3)	10	11	8
Named Storm Days (46.6)	45	55	40
Hurricanes (5.8)	6	7	5
Hurricane Days (23.9)	20	25	20
Intense Hurricanes (2.3)	2	2	2
Intense Hurricane Days (4.7)	5	5	5
Hurricane Destruction Potential (71.2) #	60	75	50
Net Tropical Cyclone Activity (100%)	95	105	85

Table 1. Gray research team's hurricane forecasts for 1996 season.

	'95 Actual	8/95	6/95	11/94
Named Storms (9.3)	19	16	12	12
Named Storm Days (46)	121	65	65	65
Hurricanes (5.8)	11	9	8	8
Hurricane Days (23.9)	62	30	35	35
Intense Hurricanes (2.3)	5	3	3	3
Intense Hurricane Days (4.7)	11.5	5	6	8
Hurricane Destruction Potential (71.2) #	173	90	110	85
Net Tropical Cyclone Activity (100%)	229%	130%	140%	140%

( ) represents the number in this category that occur in a typical year.
Hurricane Destruction Potential measures a hurricane's potential for wind and ocean-surge damage.

Table 2. 1995 hurricane activity and last year's forecasts.

Tropical Prediction Center

April - June 1996

Dr. Jack Beven
Tropical Prediction Center
Tropical Analysis and Forecast Branch

I. Introduction

April to June marks the transition between winter and summertime regimes at the Tropical Prediction Center (TPC). April usually displays a decrease in the number of cold fronts over the region. May 15 is the start of the Eastern Pacific hurricane season, while June 1 is the start of the Atlantic hurricane season. Normally, there are two to three tropical cyclones before the end of June in the Eastern Pacific and one in the Atlantic.

This year was no exception, although the period saw an unusually large number of cold fronts moving off the southeast United States coast. Hurricane season started early in both basins with several tropical cyclones and other prominent disturbances. These will be covered later.

II. What's involved in a hurricane forecast?

The start of the hurricane season is a good time to look at procedures the National Hurricane Center (NHC) uses to track and forecast tropical cyclones. All products described (and underlined) below can be found on the TPC World Wide Web (WWW) site at Universal Resource Language (URL) http://www.nhc.noaa.gov/. Note that this is an overview of NHC operations. A more detailed description of procedures and problems is found in Sheets (1990).

A. Is anything there?

NHC keeps a constant watch for weather systems that may develop into tropical cyclones. The main tool for this is geostationary satellite imagery provided by GOES-8, GOES-9, and METEOSAT-5 satellites. Images help locate areas of enhanced and persistent thunderstorm activity or cyclonic circulation which often precede tropical cyclone development. Satellite data is augmented when possible by surface observations (particularly ship

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Hurricane Prediction

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"We've seen an incredible downturn in the major Andrew-size storms over the last 25 years or so. Eventually, we'll see a return to a period when more of these major hurricanes are being formed," Gray said. "We're not sure yet, but this could be the start of that period."

Gray also says if the number of major storms increases, the potential for hurricane-spawned destruction is immense.

"Because of the build-up along the coast and the many more people living in these areas, we could see hurricane destruction like we've never seen it before," Gray said. "Hurricanes, not other natural disasters, are the single biggest natural threat to the United States."

Gray and his research team use a variety of global weather factors to produce their forecast, issued four times each year in early April, early June, early August, and again in November. The November forecast serves as a recap of the previous season's hurricane activity and the team's first look ahead at the next season.

Although several main factors are used to come up with the prediction, Gray and research team members Chris Landsea, John Knaff, Paul Mielke, and Kenneth Berry continually add to the forecast to improve it. There are five primary factors in their forecast: the strength or weakness of El Niño; the direction of equatorial stratospheric winds at 68,000-75,000 feet; rainfall in the West African Sahel region; temperature and pressure readings in West Africa; and Caribbean sea-level pressure readings and tropospheric winds at 40,000 feet.

Gray and his team also continue to monitor and add other climatological factors into the hurricane forecasts.

"We rely heavily on the El Niño and the stratospheric and tropospheric winds and the other main factors, but we also look at the globe as a whole," Gray said. "We find that the weather in Singapore, what happens in Asia, what happens in north Australia—all these things appear to influence hurricane formation because we know the globe functions as a whole."

"So the fact we had a snowy East Coast this winter, the fact the North Atlantic and Pacific circulation patterns were different and the fact we've had drought out here in the West probably indicate the atmosphere is functioning a little bit differently in the last six months," Gray said. "And that has meaning for what will happen in the current hurricane season."⚓

Tropical Prediction Center

Continued from Page 16

reports), upper air observations, and radar observations. If a disturbance looks like it is developing, an Air Force Reserve or NOAA reconnaissance aircraft will be sent into the area to collect more data.

If a disturbance persists for 12-24 hr, a hurricane specialist will mention it in the Tropical Weather Outlook. This is a narrative description of weather systems that may become tropical cyclones in the future, as well as a brief mention of currently occurring cyclones. It is issued four times a day for the Atlantic and Eastern Pacific basins.

B. Something's a-brew! What to do?

When a tropical cyclone is occurring, or a hurricane specialist determines that a disturbance is becoming a tropical cyclone, NHC follows a six-hour advisory cycle starting at a main synoptic time (0000, 0600, 1200, or 1800 UTC). This includes the following steps:

1. Analysis - where is it, how strong is it, and where is it currently going?

The first part of forecasting a tropical cyclone is determining the current speed, intensity, and movement at the synoptic time. This is not always as simple as it sounds!

In a normal case (a cyclone too far from land for air reconnaissance or radar observation), staff in the Tropical Analysis and Forecast Branch (TAFB) provides the hurricane specialist with a position and intensity estimate from satellite imagery using the Dvorak (1984) technique for tropical cyclones or the Hebert-Poteat (1975) technique for subtropical cyclones. The satellite analyst first locates the low-level circulation center. He/she then estimates the intensity based on the amount of convective banding around the system, the proximity of the center to convection, or the presence of an eye. A hurricane specialist takes this estimate, as well as a similar estimate provided by the Synoptic Analysis Branch (SAB) in Washington, D.C., and uses it as the basis for the position and intensity.

A hurricane specialist will use reconnaissance observations when available. Aircraft can determine hurricane intensity at flight level through direct measurements of wind, temperature, and pressure. This data is then extrapolated to the surface. Aircraft data sometimes give a more accurate position than satellite data at certain stages of development, particularly when a low-level center is covered with high cirrus or convective clouds.

Surface and radar observations are used when available. One well-placed surface observation (particularly a ship report) can help reveal a cyclone's location and intensity. Radar observations are most accurate on well-developed cyclones. However, the Doppler wind capability in the National Weather Service's WSR-88D is also very useful in locating weaker system centers.

There are times when various observations disagree with each other. Cyclone centers are not always well defined, and different tracking methods produce different information in such systems. Some cyclones are so poorly organized that it is difficult to locate a center at all. A hurricane specialist takes conflicting information and determines a best possible position, motion, and intensity using his/her knowledge and experience.

Once a cyclone's position, motion, and intensity are known, it is time to make a forecast.

2. Forecast – Where is it going next?

A first step in the forecast is to run guidance models for cyclone track and intensity. Track forecast models range from very simple statistical models such as the CLImatology-PERsistence model (CLIPER) to sophisticated high-resolution dynamical models such as the Geophysical Fluid Dynamics Laboratory (GFDL) model. Several models are available for every forecast. These include CLIPER, the Beta and Advection Model (BAM), and the NHC90 (Figure 1, p. 18). Several additional models are available at the 0000 and 1200 UTC synoptic times. These include the regional and global models run by the National Centers for Environmental Prediction, the Fleet Numerical Meteorological and Oceanographic Center, the United Kingdom Meteorological Office, and the European Center for Medium Range Weather Forecasts. There are a few intensity forecast aids including statistical and dynamical models. These are available for every forecast.

Model inputs include: present position, motion, central pressure, and intensity, along with vortex size and radii of tropical-storm force winds around the center. These are used in both statistical and dynamical models. Past storm intensity and position parameters are used in statistical models.

Each model uses data differently, and thus each model can give a different forecast track. At most times, tracks are similar in direction and speed, and this lends high confidence to a forecast. However, model forecast tracks occasionally point in many different

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directions. It is the hurricane specialist's job to determine which guidance is most consistent with actual weather conditions and thus may be providing the best forecast.

Figure 1 shows model forecasts for Tropical Depression One (later to become Tropical Storm Arthur) at 0000 UTC June 18. The preliminary track is noted by open circles and tropical storm symbols with labels at 24 hr intervals. Model forecast tracks are noted by black squares. Notice the good model agreement in taking the developing cyclone northwest to South Carolina. After that, they diverge. Some take the cyclone sharply out to sea, while others indicate a more northerly track. The official forecast took the depression into South Carolina and dissipated it there. However, the actual track is to the right of all models. Arthur passes over the North Carolina Outer Banks before heading out to sea. This example shows that tropical cyclone forecasts contain uncertainty even when track models are in good agreement.

Track forecast accuracy is measured by the magnitude of the distance between forecast and observed positions. NHC has an average forecast error of 95 nm for a 24 hr forecast, 180 nm for a 48 hr forecast, and 275 nm for a 72 hr forecast (based on the average of the last ten years). This means that if a storm is within 100 nm of its 24 hr forecast position, a forecast is average or better. This uncertainty must be dealt with in issuing tropical cyclone watches and warnings.

In general, the intensity forecast is not as accurate as the track forecast. Occasionally storms weaken when

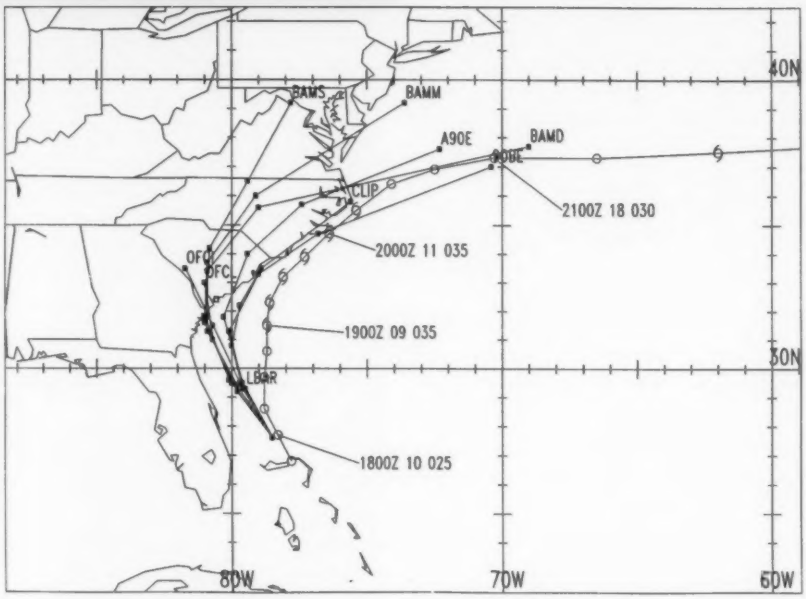

Figure 1. NHC Model guidance for Tropical Depression One at 0000 UTC 18 June, 1996, along with the preliminary track. The model forecasts are the lines with the black squares, which denote forecast times of 12, 24, 36, 48, and 72 hr. The preliminary track is marked by the open circles and storm symbols (at 6 hr intervals) and labels at 24 hr intervals.

forecast to intensify, intensify when forecast to weaken, or intensify much faster than forecast. This should be taken into account when interpreting the forecasts.

A hurricane specialist assembles his/her own forecast based on model guidance, inherent uncertainty, his/her knowledge of meteorology, and his/her experience. Once that is done, he/she moves on to coordinating the forecast and potential watches and warnings.

3. Coordination and Communication — Getting the word out!

The next forecast step is coordination with other meteorologists and with emergency managers in areas threatened by a tropical cyclone. For Atlantic tropical cyclones, a hurricane specialist has a coordination call with the Hydrometeorological Prediction Center (HPC) in Washington, D.C., the Storm Prediction Center (SPC), the U.S. Navy, and local National Weather Service offices in threatened areas. HPC and the Navy give their input on where the storm may go based on their models, with HPC also providing guidance on rainfall in landfalling storms. SPC provides guidance on tornado activity for landfalling systems. Local NWS offices coordinate with NHC on the how's, where's, and when's of watches and warnings in their areas of responsibility. A hurricane specialist uses this information to refine his/her forecast if necessary.

If a tropical cyclone is threatening a Caribbean country or Mexico, NHC coordinates warnings with local weather services and government officials. This can be a formidable job, as a storm threatening the Lesser Antilles can force NHC to coordinate

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in numerous languages with people on five or more different islands.

For a U.S. landfall, NHC coordinates with local-, state-, and federal-level emergency managers. This allows managers to start their preparations before advisories are transmitted. It also provides them with direct input into the warning process.

NHC tries to issue hurricane (or tropical storm) warnings 24 hr before the onset of hurricane (or tropical storm) conditions and watches 36 hr before such conditions. Circumstances such as a cyclone forming close to land don't always allow that much lead time, and this should be taken into account when making hurricane preparations (like a decision of whether to ride out a storm in port or at sea).

A final step is transmitting the advisories. This typically occurs about 2.5-3 hr after synoptic time. There are four parts to an Atlantic advisory package. First is the Public Advisory, which is a narrative description of a cyclone's current position, intensity, direction and speed of movement, and associated warnings. Second is the Forecast/Advisory (formerly known as the Marine Advisory), which contains a forecast track and intensity as well as forecast radii of 34, 50, and 64 kt winds. It also includes associated warnings. Third is the Tropical Cyclone Discussion, which is a hurricane specialist's description of the cyclone's meteorology, as well as his/her rationale for track and intensity forecasts. Finally, there is the table of Strike Probabilities, which lists the probability of a cyclone passing within 65 nm of a given point.

The Pacific advisory package differs from an Atlantic package in two ways. First, there are no strike probabilities. Second, public advisories are only issued when a cyclone is threatening land.

The advisory package is transmitted from NHC to Washington, D.C., where it is re-transmitted to other NWS offices and private weather services. It is then disseminated to NOAA Weather Radio, to local media outlets, to satellite weather broadcasts, and to the Internet.

4. A few extras...

Public Advisories are issued six hourly for cyclones with no associated watches or warnings. When a watch or warning is in effect, they are issued three hourly. If a watch or warning is in effect and a cyclone has a well-organized center on radar, they are issued two hourly. In addition, during two-hourly advisories, a Tropical Cyclone Position Estimate is issued at those hours when Public Advisories are not.

NHC has other tropical-cyclone related products. A Tropical Cyclone Update is issued if there is a significant change in status of a tropical cyclone (like a tropical storm being upgraded to a hurricane on the basis of reconnaissance data) and a hurricane specialist wants to give advanced notice before a formal advisory.

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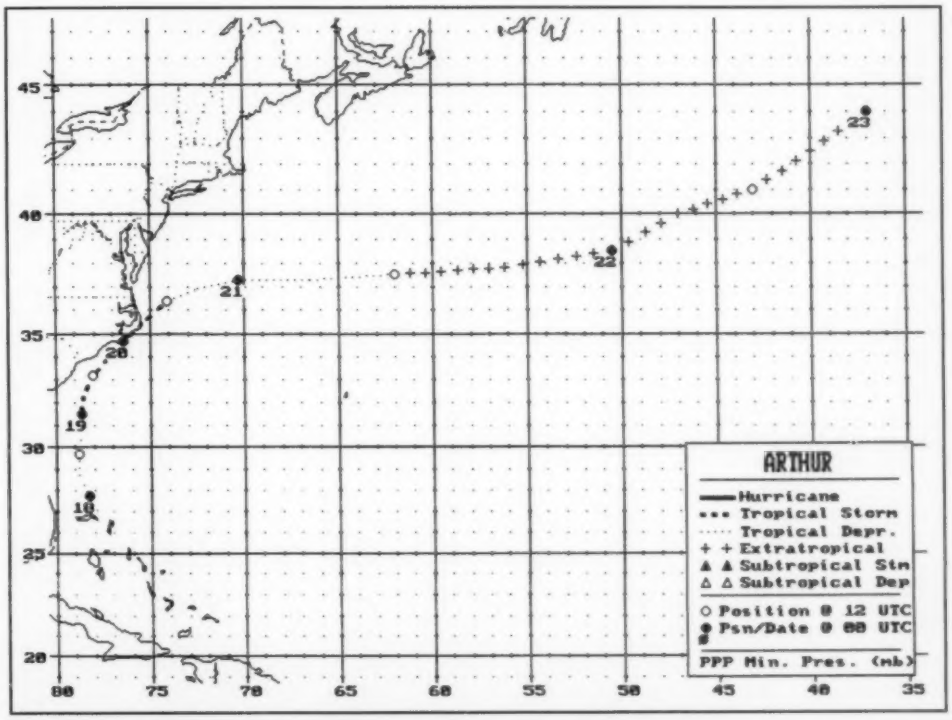

Figure 2. Preliminary track of Tropical Storm Arthur, 17-23 June 1996.

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Special Tropical Disturbance Statements are issued on systems that do not reach tropical or subtropical cyclone status, yet are still capable of producing significant weather. Finally, the Monthly Tropical Weather Summaries provide a description of tropical cyclone activity in TPC's area of responsibility during the previous month.

One final note: High Seas Forecasts issued by TAFB or the Marine Prediction Center in Washington, D.C., include forecasts on any pertinent tropical cyclones out to 36 hr.

III. Significant Weather of the Quarter

A. Tropical Cyclones - Please note that all tropical cyclone data should be considered preliminary.

1. Atlantic:

Tropical Storm Arthur: The Atlantic hurricane season started on 17 June when Tropical Depression One formed over the northern Bahama Islands. The poorly-organized system initially moved northwest, then it turned north on 18 June while slowly strengthening. The depression reached tropical storm strength on 19 June and passed across the North Carolina Outer Banks later that day. Arthur moved into the Atlantic early on 20 June as it accelerated eastward. It lost tropical characteristics near 37N 63W on 21 June. Figure 2 (p. 19) shows the preliminary track of Arthur.

Arthur was a minimal storm with maximum sustained winds of 35-40 kt. Ship C6JJ2 reported 42 kt sustained winds at 1500 UTC June 19. Automated stations at Diamond Shoals and Frying Pan Shoals reported 37 and 36 kt sustained winds respectively. An observer at Ocracoke, North Carolina, reported 33 kt sustained winds early on 20 June. Arthur did produce heavy rains over parts of the Carolinas. However, damage was minor and there are no reports of casualties.

2. Eastern Pacific:

Tropical Depression One-E: The Eastern Pacific hurricane season started before the calendar said it should have, as Tropical Depression One formed on 13 May near 11N

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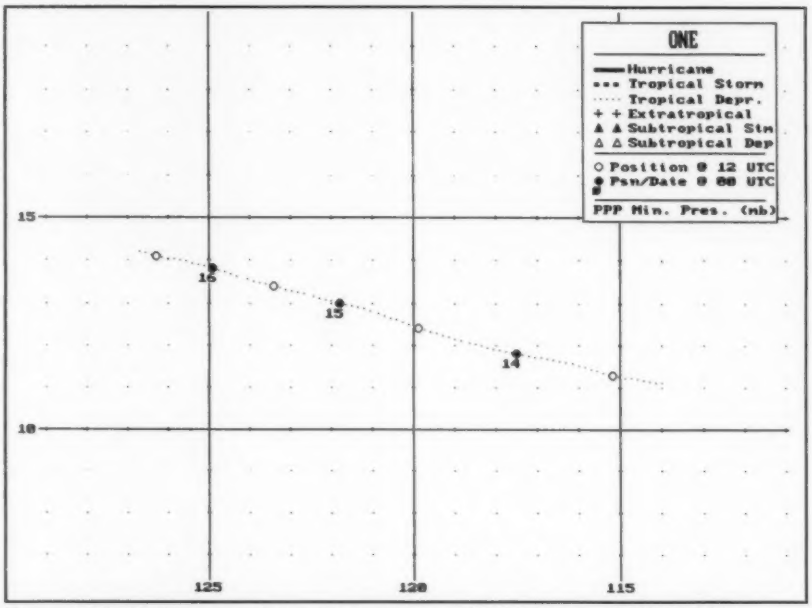

Figure 3. Preliminary track for Tropical Depression One-E, 13-16 June 1996.

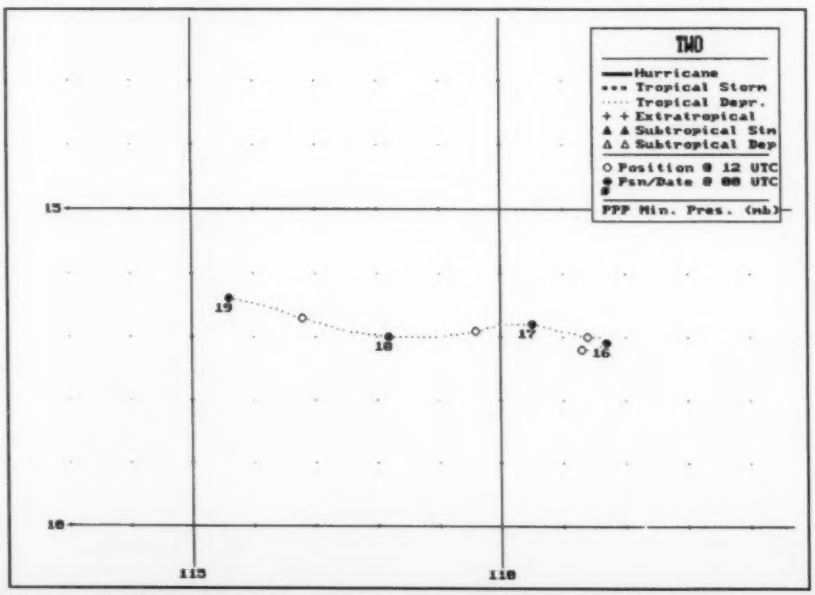

Figure 4. Preliminary track for Tropical Depression Two-E, 15-18 June 1996.

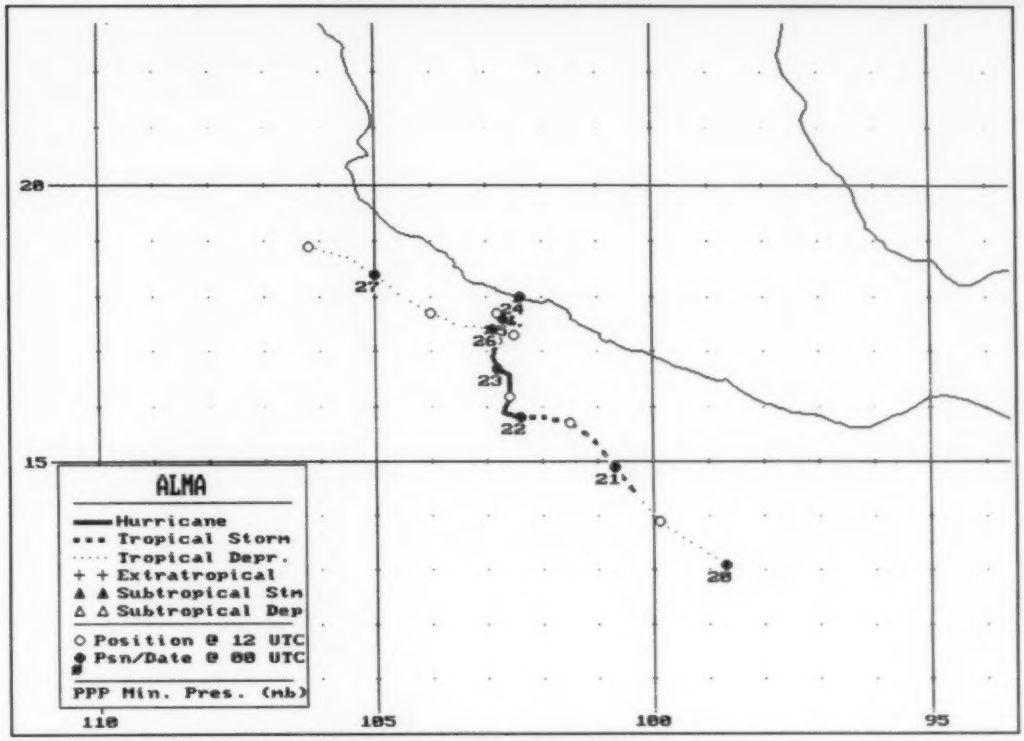

Figure 5. Preliminary track for Huricane Alma, 20-27 June 1996.

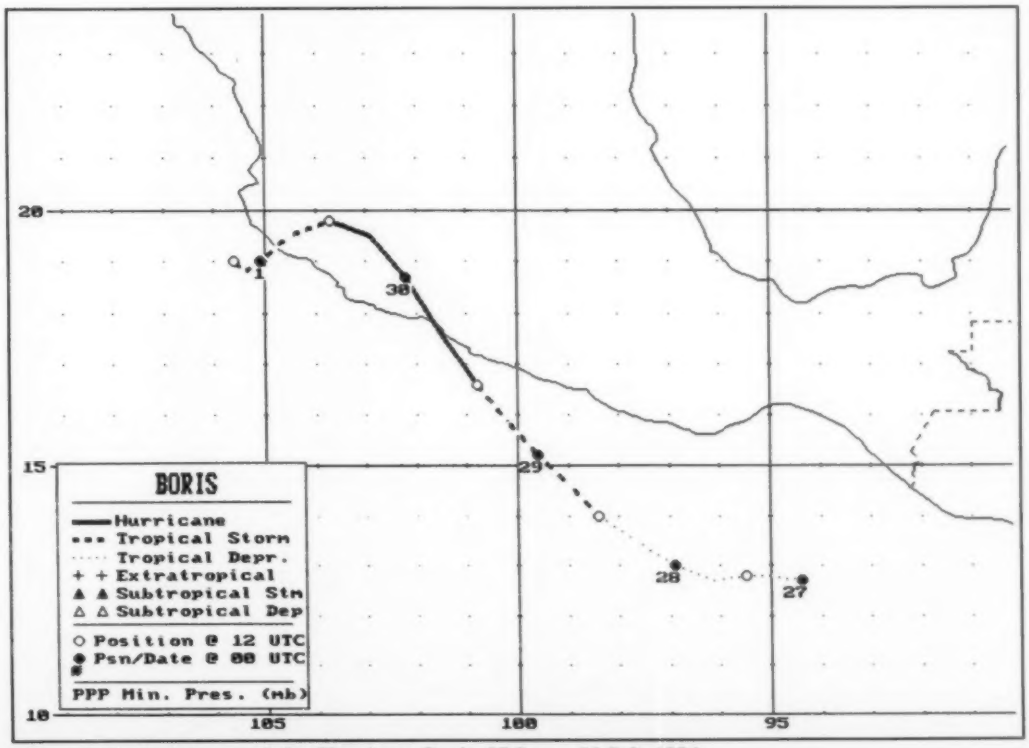

Figure 6. Preliminary track for Hurricane Boris, 27 June - 01 July 1996.

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115W (Figure 3, p. 20) from a disturbance originally detected the day before. It followed a west-northwest track and dissipated near 14N 172W on 16 May.

Maximum sustained winds based on satellite estimates were 30 kt. However, NHC has since received two late ship reports suggesting the cyclone may have reached tropical storm strength. This new data is still being evaluated.

Tropical Depression Two-E: The disturbance that became Tropical Depression Two also was first seen on 12 May. However, it took longer to consolidate and didn't reach tropical depression status until 15 May near 13N 109W (Figure 4, p. 20). The cyclone followed an erratic westward drift until it dissipated near 14N 114W on 18 May. Maximum winds were estimated at 30 kt.

Hurricane Alma: Tropical Depression Three-E formed near 13N 99W on 20 June. It followed a northwest track for two days as it reached tropical storm (20 June) and hurricane (22 June) strength (Figure 5, p. 21). Alma then began an erratic northward drift that brought it to the Mexican coast near Lazaro Cardenas near 0000 UTC 24 June at its peak intensity of 85 kt. With its eye half onshore, Alma changed course and drifted southwest back out to sea.
Alma then drifted erratically northwest for two days. It weakened to a tropical storm early on 25 June, then to a depression later that day. Alma dissipated near 19N 106W on 27 June.

Alma's aborted landfall brought hurricane conditions to Lazaro Cardenas. Its slow motion also resulted in heavy rains over other parts of southwest Mexico. These conditions produced floods, mudslides, and property damage. There are unconfirmed reports of 10 deaths associated with Alma.

Hurricane Boris: Tropical Depression Four-E formed near 13N 94W on 27 June. It first tracked west, then turned northwest on 28 June as it reached tropical storm strength (Figure 6, p. 21). Boris continued northwest and crossed the Mexican coast between Lazaro Cardenas and Acapulco with 80 kt winds on 29 June. Boris turned west and southwest while over land on 30 June, and it reached the Pacific again on 1 July. Boris could not recover, and it dissipated near 19N 106W later that same day.

Boris brought tropical storm and hurricane conditions to a large part of the Mexican coast, including areas affected by Alma just a few days before. Press reports indicate that one death was attributed to Boris.

B. Other systems

The most significant other system in the TAFB area of responsibility was an early and complex tropical disturbance that affected an area from the western Caribbean across Cuba and Florida into the Atlantic.

Cloudiness and thunderstorms began increasing over the western Caribbean on 17 May in response to a broad low pressure system over Central America and an upper level trough over the Gulf of Mexico. A poorly defined circulation developed over the northwest Caribbean on 18 May and drifted north. Early on 21 May a new circulation started forming over the eastern Gulf of Mexico while the original low weakened over the Yucatan Channel. The new center was directly under an upper level low and thus was more subtropical than tropical in character. Convection tried to consolidate around the second low, but it weakened as a third circulation developed over the Florida east coast early on 22 May. This low reached its maximum strength later that day, and gradually weakened thereafter. The third low tracked east-northeast and then east to near Bermuda (24 May) and was last detectable near 31N 54W on 26 May.

None of the three circulations developed enough convective organization to be considered a tropical cyclone. Surface data and reconnaissance reports indicate the system produced 20-30 kt winds over parts of the Caribbean, Gulf of Mexico, and the Atlantic. It should be noted that while the upper level trough/low prevented tropical cyclone formation, it provided the upper level support necessary for the series of lows.

This tropical disturbance produced heavy rains from south Florida southward across Cuba to Jamaica and the Cayman Islands.

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Climate Prediction Methodology

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There is a surprising degree of seasonal to year long climate predictability potential in atmosphere and ocean data sets. The atmosphere has a much longer memory for changes in its future state than one would surmise.

The development of new climate prediction schemes should be based on how the atmosphere-oceans have behaved in the past. This hindcasting methodology appears to offer much more likelihood of success than do climate forecasts made from the initial value numerical model approach which is so in the vogue at this time.

1. Background

Variations in Atlantic seasonal tropical cyclone activity and other seasonal climate phenomena variability including ENSO, Asian monsoon rainfall, North African seasonal rainfall, etc., are products of the longer term variability of the global circulation. One cannot explain the variability of these phenomena by looking only at local or regional climate parameters. The global atmosphere functions as a single entity. Our project's climate research in recent years is finding that there are a surprising number of seasonal and yearly predictive signals that reside in the global circulation. These predictive signals include the stratospheric QBO, Singapore 100 mb temperature anomalies, the strength of the northeast Atlantic pressure ridge, North Atlantic sea surface temperature (SST) anomalies, multi-month upper tropospheric mean zonal winds and values of multi-monthly surface pressure and rainfall anomalies at various locations around the globe. Figures 1 and 2 show the locations of some of our predictive signals.

There has been a general belief that only the ocean, not the atmosphere, has long term predictive signals. This is based on the knowledge that the atmosphere's hydrologic cycle and its kinetic energy dissipation rates operate on a time scale of about ten days. One would not think that the atmosphere would have sufficient memory so as to possess useful season to year long predictive signals. Most statistical climate forecast schemes use only SST information. This view of the atmosphere as having no long term memory is not correct. There are many long period predictive signals which reside within the atmosphere, even if these atmospheric predictive signals are a consequence or proxy response for what is occurring within the oceans.

Although the atmosphere may be an ocean forced system, ocean measurements are typically less accessible and do not extend back in time as long as atmospheric measurements do. One can often learn of the characteristics of the ocean better from atmospheric measurements than from direct but deficient measurements of the ocean itself. We find this to be the case. The atmosphere has much more knowledge as to the future state of the combined atmosphere-ocean system than does the ocean by itself.

The combination of global oceanic and atmospheric measurements allow a substantial degree of statistical likelihood for seasonal and year-to-year prediction. Examples of meaningful season to year long statistically predictive signals of seasonal Atlantic hurricane activity are the El-Niño-Southern Oscillation (ENSO), African rainfall, and Asian rainfall. We are presently making such predictions. But these examples are far from complete. We have only scratched the surface. It is to be expected that further observational research will uncover many more atmospheric measurements that can be utilized to allow for skillful season to year-in-advance statistical prediction of other phenomena. We are also exploring the possibility of issuing statistically meaningful outlooks of what might be expected with regard to changes in the global circulation and various weather phenomena one to three decades into the future based on Atlantic Ocean thermohaline conveyor belt alterations.

2. Methodology

The methodology for detecting these predictive relationships is based on the assumption that the changes in future atmospheric-ocean conditions will mimic those for similar atmospheric-ocean conditions which have occurred in the past. The documentation of past atmospheric and ocean records with sophisticated data storage and retrieval procedures on computers is allowing for in-depth analysis of historical weather records not possible in the past. These records throw new light on how the atmosphere and ocean undergo season to year to multi-decadal alterations.

This observationally based research approach is a very promising area for research; there has, however, been insufficient resource commitment to it. This is due to:

1. The general belief that few really extended range atmosphere-ocean precursor signals are present in historical data. This is not true, they just have not been thoroughly investigated.
2. The false notion that the best methodology for climate prediction is that of initial-value numerical modeling.

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Climate Prediction Methodology

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The likely superiority of the empirical approach to the development of useful climate prediction schemes is due to the complex nature of the atmosphere-ocean system and to the inability of the numerical models to realistically represent this physical complexity and then forecast this into the future. Imperfect representations of the highly non-linear atmosphere-ocean systems tend to quickly degrade into unrealistic flow states upon long integration period. The specification of the atmosphere's complicated energy and momentum exchange processes, cloud and rainfall processes, cloud versus cloud free and day versus night radiation processes, earth surface to atmospheric exchange processes, etc., etc., cannot now and likely never will be well enough parameterized in coarse grid numerical models such that long-lead climate predictions can be made with much skill—particularly skill which is greater than that of empirical-based forecasts.

Although initial value numerical prediction has been a great success story for predictions of 5-10 days (where heavy reliance is placed on extrapolation of the momentum fields) such successes cannot be automatically extrapolated to the very different and much more complicated problem of the prediction on seasonal and yearly time scales.

The boundary forced climate models do not utilize knowledge of how the atmosphere-ocean has behaved in the past; they only use current boundary conditions. Conceptually one might say that such models lack culture. They imply a presumed knowledge of how the detailed physics of the atmosphere works and the ability to realistically parameterize this detailed physics for thousands and thousands of time steps into the future. This is not possible.

This does not mean that some effort at climate modeling should not go forward to gain basic knowledge. Improved knowledge can and is coming from climate modeling. Climate models can explore sensitivity to individual parameter alteration on large time scales. Such modeling can help verify or reject various physical hypotheses. But one must realize that climate models are not (and likely never will be) a practical tool for reliable long lead climate prediction. It is important that one make a distinction between general climate understanding and climate forecasting. The two are not the same. It is unfortunate that such a high percentage of climate resources are being expended on climate modeling at the expense of observational and empirical studies which offer a much higher potential for skillful prediction.

The advantage of statistical climate forecasting over boundary condition climate modeling lies in the complex structure of the atmosphere-ocean system. One does not have to understand all of the complicated and involuted physical details of the atmosphere-ocean system to predict it. One only need learn of the time lags of various physically important climate parameters and how they relate the climate change. Physical understanding follows observations, not the other way around. By contrast, boundary condition numerical modeling requires full knowledge of the complicated physics in advance.

The author would like to acknowledge the many beneficial discussions he has had with his colleagues Christopher Landsea, John Sheaffer, John Knaff, Paul Mielke, and Ken Berry.

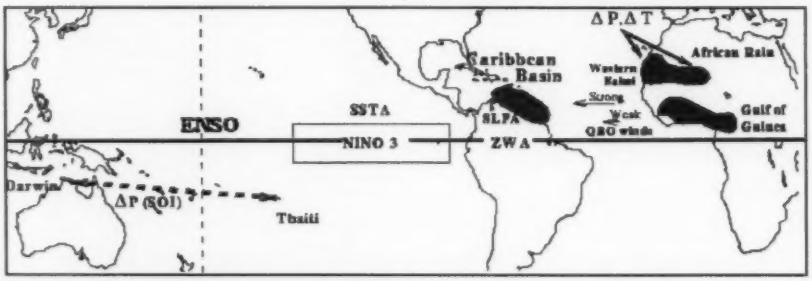

Figure 1. Meteorological parameters used in our various late November, early April, early June, and early August forecasts.

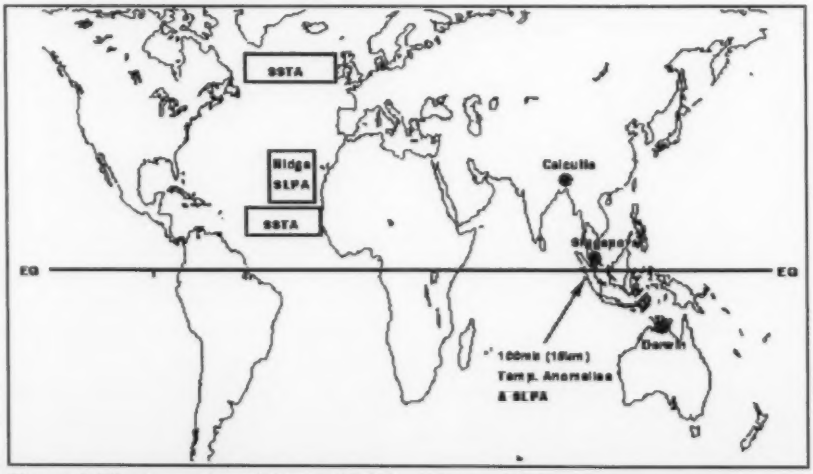

Figure 2. Most recent predictors which have been added to our forecast pool.

Colorado State University Professor William Gray and His Research Team Use Global Weather Patterns to Predict Hurricane Formation in Atlantic Basin

Colorado State University Professor William Gray and his research team use many global weather factors to predict, in advance, what will happen during the hurricane season.

Simply put, the research team looks for signals in weather around the globe to issue their four seasonal hurricane forecasts. Although the forecast is continually updated, and new weather features are constantly being added, there are some basic factors that Gray and his research team rely on in their work.

These factors, and a brief explanation of their importance in the formation of hurricanes, are listed below. Gray's hurricane forecasts predict the number and severity of storms that will occur in a hurricane season. The forecasts, which do not predict landfall, apply to storms that will form in the Atlantic Basin—the area including the Atlantic Ocean, Caribbean Sea, and the Gulf of Mexico.

None of these listed forecasting signals, in and of themselves, will indicate whether the upcoming season will be active or quiet. Taken together, however, these signals have helped Gray and his research team develop an impressive track record for predicting hurricane formation.

El Niño

The El Niño is a warm-water pattern off the coast of Peru. When the El Niño is present, water temperatures reach about 27 to 29 degrees centigrade, or about 1 or 2 degrees centigrade warmer than normal. This rise in ocean temperature causes winds to blow in a westerly direction from the Pacific Ocean across to the Atlantic Ocean. These tropospheric winds, which blow at about 40,000 feet, act to shear off and inhibit weather systems from developing into hurricanes. When the El Niño is not present, these winds are not developed and therefore do not act to thwart hurricane formation.

West African Rainfall

The rainfall levels in the west African region known as the Sahel greatly influence hurricane formation. When it is drier than normal in the Sahel, winds at about 40,000 feet (the same tropospheric winds influenced by El Niño) blow off the African continent and act to shear off the top of storm systems, or depressions, that eventually could become hurricanes. When it is wet or when normal rainfall conditions are present, these winds are not present and these storms are better able to turn into hurricanes as they head into the Atlantic Ocean. The Sahel normally gets about 15-20 inches of rain during its June through September rainy season. About 95 percent of the rain in this region comes during that time. The storms that form in Africa often are called the seedlings of hurricanes because they often will form over the continent and continue to strengthen into hurricanes as they move into the Atlantic.

West African Surface Temperature and Pressure

In this complex portion of the forecast, Gray and his research team compare the temperature and barometric pressure readings in two different African regions from February through May as an indicator of future hurricane activity. This factor is used in the June and August forecasts. Gray compares a western coastal region of the continent that includes portions of the countries of Senegal, Gambia, and Guinea to a more central region of the continent that includes portions of the countries of Niger, Nigeria, and Chad. To put it simply, when the pressure is lower and the temperatures are higher in the coastal region, it promotes southerly winds which help in hurricane formation—or the evolution of these seedlings into the major storms. When the pressure is higher and the temperatures are lower in this costal region when compared to the central region, then the southern winds are not present to promote hurricane formation.

Stratospheric Winds

Gray and his team carefully monitor the direction of upper-level winds. This is a key forecasting tool known as the stratospheric Quasi-Biennial Oscillation, or QBO influence. The winds at 68,000-75,000 feet usually blow one direction for about a year, then turn around and blow in the opposite direction for about a year.

When these winds blow from the west, there is nearly twice as much lower-latitude hurricane activity as when these winds blow from the east. To sum it up, easterly winds at this level hamper hurricanes, westerly winds don't.

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Professor William Gray and His Research Team Use Global Weather Patterns to Predict Hurricane Formation in Atlantic Basin

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Tropospheric Winds

Gray and his research team pay close attention for the June and August forecasts to the tropospheric winds at 40,000 feet that blow all around the globe. These winds—which are heavily influenced by El Niño, African rainfall, and Caribbean Sea pressure readings—will inhibit hurricane activity if they are blowing weaker than normal from the west. However, these same winds will promote hurricane activity if they are blowing stronger than normal from the east. The influence derived from the direction of the tropospheric winds is just the opposite of the influence of the stratospheric winds, which blow at 68,000-75,000 feet and are listed above.

Caribbean Sea-Level Pressure Readings

When the barometric pressure readings are lower than normal in the tropical Caribbean and Atlantic, the conditions are ripe for hurricane formation. Hurricanes start as depressions and as they grow in strength, the pressure readings inside the storms continue to drop. If the pressure in the areas where the storms are growing in strength is low, this helps with the development of depressions into tropical storms, then into hurricanes. In other words, low pressures help to give hurricanes a boost. If the pressure levels are higher, then depressions are less likely to evolve into hurricanes. Normal barometric-pressure readings in this area are about 1,015 millibars. Pressure readings of only one or two millibars below normal help promote hurricane formation while pressure one to two millibars higher greatly inhibits hurricane development.

The Oceanic Conveyor Belt

This is not a forecasting tool for Gray's annual hurricane forecasts but a long-range indicator of possible trends in hurricane activity. Water in the oceans circulates in a giant pattern through the Pacific Rim and Indian Ocean up the west coast of Africa, into the polar regions, where it is chilled and then sinks back to lower levels before returning south. Gray believes this circulation pattern has slowed down over the last 25 years, which has created drier conditions in Africa and upper-level wind conditions that have worked to inhibit hurricane formation. Gray believes this circulation pattern will speed up in the next few years, which will lead to an increase in hurricane activity.

Global Warming and Hurricane Activity

Gray emphatically denies any link between global warming and an increase or decrease in hurricane activity. He points to the hurricane seasons early in this decade—the most inactive consecutive seasons in history—as a rebuttal to those who would claim global warming caused the dramatically active 1995 hurricane season. "If global warming was responsible, why then would the previous years have been so inactive?" Gray believes hurricane activity runs in decades-long cycles that have been in a downturn for nearly three decades.

"I'm not sure when we will see a return of more active storm periods, but we will certainly see an upswing of activity," Gray said. "And when we do, we are going to see more hurricane-spawned damage than we've ever seen before because of all the build-up in coastal regions."

Landfall and Gray's Forecasts

Gray does not predict where storms will come ashore, or even if they will. His forecasts deal solely with the number and severity of storms that will form in the Atlantic Basin. He cautions against not taking precautions in years when the forecast calls for below-normal hurricane activity.

"Statistically speaking, 1992 was a very inactive year for hurricanes. We only had one intense storm. But that storm was Andrew, and it spawned nearly 30 billion dollars in hurricane destruction. It is important to prepare for hurricanes, because even in relatively inactive years, you never know when we will see a major landfalling storm."⚓

For further information regarding Professor Gray's studies, please visit the Colorado State University's home page on the internet at the following address:

http:/tropical.atmos.colostate.edu/forecasts

Physical Oceanography

The Ocean's Ups and Downs

Bruce Parker, National Ocean Service

As huge as the ocean is, and as interesting as the mysterious ocean depths may be, it is the ocean's surface that is clearly most important to us. The fact that the ocean's surface moves up and down has significant consequences for ships, beaches, and homes near the water's edge. The most familiar examples of the up and down movement of the ocean's surface are the waves generated by the wind. There are also much larger movements, such that a significant portion of the ocean surface (on which these waves propagate) moves up and down, often dramatically in coastal areas. We refer to this as changing *water level*, and in this column we will look at its causes (we will save the topic of wind waves for another column).

The illustration below shows various phenomena that can cause or influence changes in water level. Most of the time in most coastal areas the major cause of changing water level is the *astronomical* tide, namely, the change in water level due to the changing gravitational effects of the moon and the sun as they change position relative to the earth. We emphasize the word "astronomical" because the word "tide" has often been used for all changes in water level, no matter what the cause. Oceanographers use the term "water level" as the most general, all-inclusive term, with the "tide" referring only to the effects of the moon and sun. Water level changes caused by the wind and barometric pressure are usually referred to as *storm surges*. The term "sea level" is used for longer-period, slower changes in water level. Mean Sea Level is the average of water level measurements

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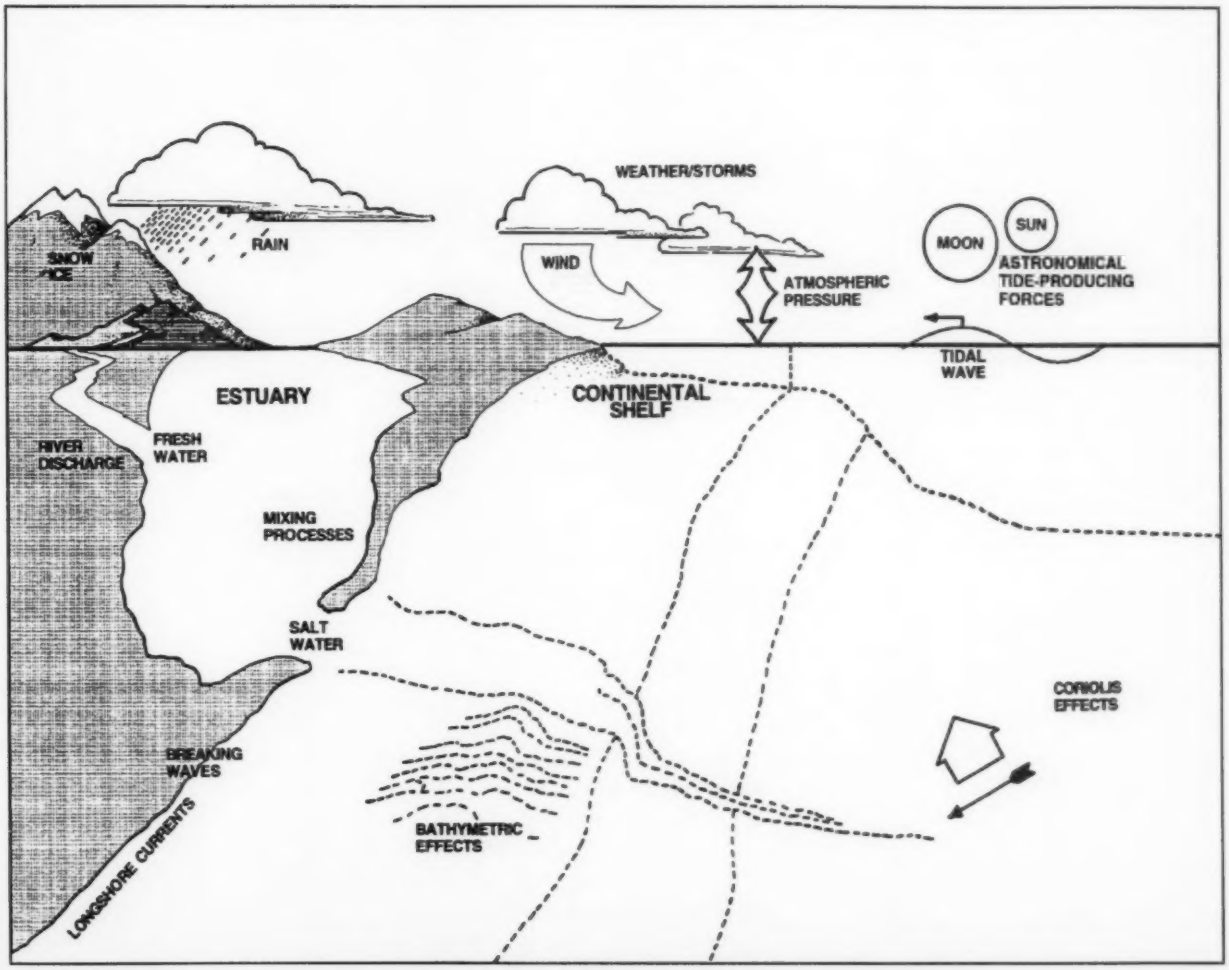

The Ocean's Ups and Downs

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over some time period, such as a day, a month, or a year. When an oceanographer averages a day's worth of water level data to calculate a daily Mean Sea Level, this process averages out shorter-term oscillations like the tide.

Water level is the height of the water surface above some reference level, called a *datum*. Datums for a particular waterway are generally defined by the astronomical tide. In particular, *chart datum*, the reference level for all depth soundings on a nautical chart, is defined in the United States as the Mean Lower Low Water (MLLW) at each location. *Lower low water* is the lower of the two low waters that occur each day (in most regions), and the MLLW is the average of all the lower low waters for a year (or more). Tidal datums also provide the legal definition of *marine boundaries*. MLLW is the dividing line between Federal territorial seas and State submerged lands, and Mean Higher High Water (MHHW) is the dividing line between State tidelands and private uplands.

The astronomical tide dominates our thinking about changes in water level, not only because it usually causes the largest changes, but also because it is very predictable (especially in comparison to how well we can predict the weather). After analyzing only a month's worth of water level measurements from a tide gauge we can predict the tide quite accurately (for that location) for years into the future. The reasons for this high predictability will take a column by itself to explain, but essentially it is due to the tide's periodic nature and the fact that astronomers have provided oceanographers with very precise information about the orbit of the moon around the earth, the orbit of the earth around the sun, and the turning of the earth on its axis. Tidal energy is found at the same *frequencies* that describe these orbital motions.

Tidal (gravitational) forces generate very long waves in the ocean (thousands of miles long but not very high), which propagate onto the continental shelf and up into bays. This tidal wave (not to be confused with an earthquake-caused tsunami, itself another cause of a rather dramatic change in water level) is partially reflected at the edge of the continental shelf and fully reflected at the ends of bays, leading to an increase in tidal range. Each bay has a natural frequency of oscillation determined by its length and depth (much like the natural frequency of an oscillating pendulum is determined by its length). The water surface in a very small container, like a coffee cup, oscillates quickly when the cup is moved. In a larger container, like a bathtub, the water surface sloshes back and forth more slowly. In a huge bay it takes hours for its water surface to oscillate back and forth when it is moved. If the bay's natural frequency is close to the primary tidal frequency (approximately two cycles per day), the tidal range will be greatly increased (because the tidal forcing would be pushing the water upward at the same time the water would be moving upward from its natural oscillation). The extreme example of this *resonance* is in the Bay of Fundy in Canada, where the tide range can be 50 feet (15 meters).

After the tide, the wind has the greatest influence on water level, and in many areas it can be the dominant factor, especially during storms (when the rising water level can cause flooding). In shallow-water areas an onshore wind pushes water toward the shore, raising the water level (*wind setup*). An offshore wind pushes the water away from the shore, lowering the water level (*wind setdown*). The usually more dominant wind effect on coastal water levels, however, is caused further offshore by the *longshore wind component*. A longshore wind, blowing parallel to the coast, will raise or lower the water level because the *Coriolis force* causes water transport to the right of the wind direction (in the Northern Hemisphere, but to the left in the Southern Hemisphere). Coriolis force is the effect of the Earth's rotation on moving objects. When an object (such as water) moves fairly slowly over large distances in a straight direction (a straight direction relative to some absolute reference system, like the stars), the Earth has time to rotate under this motion, so that, when we look at the water's motion relative to the (rotating) Earth, the water appears to curve to the right (in the Northern Hemisphere). Thus, the surface current caused by the wind will move a little to the right of the direction of the wind. The surface current will cause a current deeper in the water column which will go a little slower and in a direction a little to the right of the surface current. As we go deeper, the current keeps getting slower and flows in a direction further to the right of the current above it. The entire flow picture is a spiral (the Ekman spiral). Averaged over this entire spiral, however, water is transported perpendicular to the right of the wind direction. So, for example, if the wind is blowing toward the south, parallel to a coastline running in a north-south direction, then the water being pushed to the right (westward) would pile up against the coast and raise the water level.

The importance of wind effects on water level is illustrated in the graph on page 29, which shows a plot of the measured water level (the solid line) at Baltimore Harbor on the Chesapeake

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Bay for several days in December 1993. The dashed line shows the tide prediction for that same time period. The difference in the two curves is due to the effect of the wind, both on the waters of Chesapeake Bay and on the waters of the Atlantic Ocean outside the Bay's entrance, out to the edge of the continental shelf.

Atmospheric pressure also affects water level. Increased pressure pushes the water down, decreasing the water level. Decreased atmospheric pressure essentially allows the water to rise up, increasing the water level. This is known as the inverted barometer effect. *River discharge* can raise water level in an estuary. For high enough flows bottom friction causes the river water essentially to back up, raising the water level. Further down the estuary there may also be a smaller increase in water level due to the addition of fresh water, which, being less dense than salt water, takes up more room and raises the water's surface. Changes in water density, called *steric* changes, change the water level. In the open ocean such changes are caused by temperature changes in the water column. Warmer water expands and pushes the water surface higher. Cooler water contracts, lowering the water level. The largest changes in water level caused by this thermal expansion or contraction usually correspond to seasonal changes in temperature, namely, summer sea level will be higher than winter sea level.

Monthly mean sea level values have averaged out the tide and other shorter-period oscillations, leaving variations in water level caused by seasonal variations in water temperature or wind. Yearly mean sea levels eliminate these seasonal variations and leave longer-term variations (2 to 7 years) caused by, for example, the effects of El Niño - Southern Oscillation (ENSO). Even longer variations in sea level related to climate change can occur, and there have been many investigations trying to demonstrate an effect of global warming on sea level

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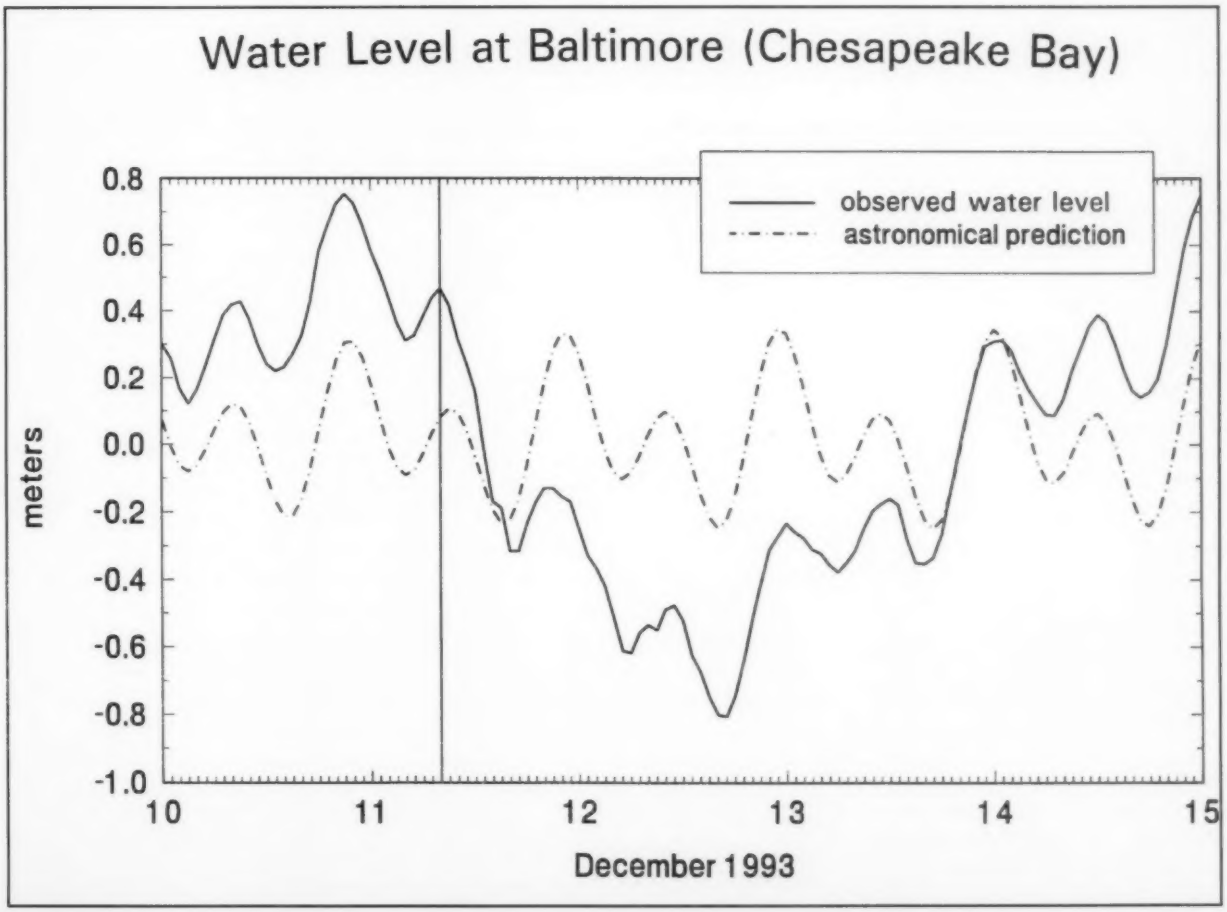

Underwater Archaeology

Submerged Bottom Lands

Richard Lawrence and
Mark Wilde-Ramsing
North Carolina Division of Archives and History
Underwater Archaeology Unit

North Carolina has a long and rich maritime history. With over 300 miles of ocean shoreline, a vast inland sea formed by the coastal sounds, and thousands of miles of navigable rivers and creeks, the people of North Carolina have long relied on the state's waters as a means of transportation and trade and a source of livelihood. Coupled with this active maritime history, the treacherous geography of the North Carolina coast has led to countless shipwrecks. Naval warfare, particularly during the Civil War, has created additional losses.

The 1967 statute that created the Underwater Archaeology Unit (UAU) (NCGS 121 Article 3) asserted the State's title to "all bottoms of navigable waters within one marine league [three nautical miles] seaward from the Atlantic seashore" and claimed ownership for the state of "all shipwrecks, vessels, cargoes, tackle, and underwater archaeological artifacts which have remained unclaimed for more than 10 years lying on said bottoms, or on the bottoms of any other navigable waters of the State." The statute also authorized the Department of Cultural Resources to establish a professional staff and formulate rules and regulations to manage these submerged resources, and develop a permitting system to allow other individuals, groups, and institutions to conduct investigations and recovery projects of the state's underwater archaeological sites. That state statute was strengthened with the passage of the federal Abandoned Shipwreck Act in 1987. These laws mandate responsibility for an enormous expanse of submerged bottom lands and the shipwrecks and other archaeological sites they contain. If the offshore ocean waters out to the three mile limit are combined with the interior sounds and rivers, the Department of Cultural Resources is responsible for managing cultural resources on 4,374 square miles of bottom land, an area only slightly smaller than the state of Connecticut.

For the past thirty years, the Underwater Archaeology Unit of the Archaeology and Historic Preservation Section

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The Ocean's Ups and Downs

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(which so far have been inconclusive). In some locations very slow sea level rise is actually due to the land sinking, caused by such things as glacial rebound since the last ice age, tectonic activity, sediment compaction, or the extraction of water or oil from the ground. The greatest change in sea level occurs between the time of an ice age, when much ocean water is locked up in glaciers, and the following warmer interglacial age, when the glaciers melt. During the last ice age, 18,000 years ago, sea level was approximately 443 feet (135 meters) below what it is today.

For the purposes of predicting water level for the mariner, however, all these slow changes are not a problem, because they don't cause significant changes from one day to the next. It is the tide (which goes through one cycle in approximately 12.42 hours) and the wind-induced and river-induced changes (which vary over a period of hours to days) that must be accurately predicted. For a ship entering or leaving a port, knowing the water level is critical if it is to avoid running aground. The depth soundings shown on a nautical chart used by the pilot are the water depths relative to the chart datum, namely, when the tide is at its lowest (at MLLW). The pilot must know the exact water level and add it to the depth sounding shown on his chart to determine the actual water depth he has to work with.

For more than a century mariners have relied on published Tide Tables for information on water level. These tables, however, provide only astronomical tide predictions and cannot include the effects of the wind or river discharge, which can make a crucial difference in water level, especially for a huge cargo ship or tanker, which may not even be able to enter the port except near the time of high water. Every additional inch of water depth under keel can make a difference, both from a safety point of view and from an economic point of view (in terms of carrying more cargo or leaving port earlier). Thus, the U.S. and many other nations have begun using data acquisition and dissemination systems to provide actual measured water level data to the pilots, Coast Guard, and others in the maritime community, in real time (i.e., within minutes from the time the measurement was made). In order to provide short-term forecasts of the part of the water level change due to the wind, river, and other nontidal effects, these nations are also implementing sophisticated forecast ocean models, which are forced with winds and other output from forecast weather models.⚓

Submerged Bottom Lands

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has made steady progress in its efforts to understand and manage the state's submerged cultural resources. The Unit has documented over 700 underwater archaeological sites that include prehistoric dugout canoes, colonial sailing vessels, beached shipwreck remains, dozens of Civil War shipwrecks, and nineteenth and twentieth century steamboats. The Unit also maintains extensive files on nearly 4,000 historically documented shipwrecks, as well as on a wide variety of water-related subjects such as bridge and ferry crossings, historic ports, plantation landings, riverine and coastal trade, harbor development, and improvements to navigation.
The following summary of the UAU's activities over the past year gives a good picture of how the UAU, often working with other agencies and institutions, manages the State's submerged cultural resources through a program of public education, site development, and field research.

The underwater archaeology educational outreach program, *Hidden Beneath the Waves*, developed by the UAU and Cape Fear Museum, highlights the unit's educational outreach efforts. Two outreach kits, each featuring a model of a different shipwreck, are now available to area middle school teachers for a four-week period. This year it is estimated that over three hundred students in the Wilmington, North Carolina, area will participate in this exciting, hands-on classroom experience.

Targeted for 8th grade students, each self-contained outreach kit provides video presentations, historical research exercises, quiz games, and the mystery wreck model to be identified by students. Solving the mystery wreck is the highlight of the four-unit program; it involves working with historical maps, artifacts, and a four-foot model of an actual shipwreck currently lying at the bottom of the Cape Fear River.

Since the groundwork has been laid, *Hidden Beneath the Waves* may be adopted to other coastal regions by focusing on the geography, maritime history, and shipwrecks found in those areas. Furthermore, a good understanding now exists of what elements need to be in place to administer and

successfully run the program, it's overall costs, and how local funds can be raised to meet those costs.

Since the creation of North Carolina's first Historic Shipwreck Preserve in 1992 at the USS *Huron* site, UAU staff members have searched for other potential shipwreck preserve sites. Unfortunately, the *Huron* shipwreck is relatively unique in the state since it provides an accessible beach dive with good visibility in a populated area. The vessel also has an interesting history and its remains are well-preserved with recognizable features such as the boilers, propeller, and rudder. On the other hand the vast majority of recreational dive sites in coastal waters lie outside of North Carolina's three-mile limit and UAU's jurisdiction. While there are numerous sunken vessels within state waters, on a whole they are in areas of low visibility and strong currents where safety is a serious concern. A few others that might serve as good shipwreck preserves are located in non-populated areas, such as the vacant stretches of the Outer Banks, that are far from dive shops and community support. There would be neither local sources for funding or surveillance—important elements of prospective preserves.

To overcome the shortcoming of preserve sites, the UAU is exploring a new avenue for public education and community involvement—the Shipwreck Overlook. Overlooks would feature octagonal wooden gazebos placed along the shoreline adjacent to shipwreck sites. Within the gazebo, display panels would present photographs and informative text concerning the ship's history and the circumstances surrounding its sinking. As with the *Huron* preserve, the UAU would provide the historical information and gazebo plans, while the local community would pay for materials and be responsible for maintenance. The actual construction would be a joint effort.

This fall the first North Carolina Shipwreck Overlook will be built by the Town of Carolina Beach, Federal Point Historic Preservation Society, and UAU along the ocean shoreline below Wilmington near the site of the Civil War blockade runner *General Beauregard*. On the night of December 11, 1863, the Union fleet chased the sidewheel steamer ashore one mile

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Submerged Bottom Lands

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south of Gatlin's Battery near what is today Carolina Beach. The *General Beauregard* was headed for Wilmington with a cargo of brown sugar, coffee, bacon, and candles when it sank. Although seldom visited by sport divers, the exposed remains of the paddlewheel hubs at low tide are a curiosity to thousands of tourists that visit the beach annually. UAU staff members are excited about the Shipwreck Overlooks for they can serve as an effective and inexpensive way to promote community awareness and pride in local maritime history and submerged archaeological resources.

The UAU staff has also recently been involved in a variety of research activities, the majority of which were a cooperative venture with staff and graduate students from East Carolina University's Program in Maritime History and Nautical Archaeology. In May, a week-long expedition headed for Ocracoke, on the Outer Banks, to study the nearly inundated island known as Shell Castle. Located on the inside of the inlet, and adjacent to the deep water channel, this small isle complete with wharfs, warehouses, houses, and a lighthouse served as a vital transshipment point from 1790 until the early 1800s. It was reportedly one of the most valuable pieces of property in the country at that time. East Carolina University (ECU) graduate student Phil McGuinn is combining field data with extensive historical research to reconstruct life on Shell Castle for his master's thesis.

In June, a field school under the direction of Dr. Larry Babits (ECU) was conducted at the shipwreck site of a centerboard schooner in Chocowinity Bay near Washington, North Carolina. That site was discovered during the construction of a large marina. The Unit negotiated with the developer, Weyerhaeuser Real Estate Company, to alter marina plans and thus protect the site until a thorough examination and assessment could be conducted. During the ECU field school, the shipwreck was identified as a previously undocumented ship type exhibiting a square transom and identical square bow. This scow-like sailing vessel was most likely built in the Albemarle region of the state shortly after the Civil War and used for transporting bulk cargoes such as bricks in the local sounds and rivers.

Ann Merriman, an ECU graduate student, who was field supervisor for the Chocowinity Bay shipwreck study, then served as an intern with the UAU at Fort Fisher. Her primary task was to reorganize the UAU research files which consist of records on historic shipwrecks, archaeological sites, and an extensive array of materials on historic water-related activities, artifact analysis, and maritime subjects. Ann also revised and updated the UAU bibliography for underwater archaeological sites and survey reports conducted in North Carolina.

Another ECU graduate student, Nathan Henry, also interned this summer at Fort Fisher. His primary responsibilities involved working in the conservation lab where he prepared the large collection of USS *Underwriter* artifacts for transfer to the CSS *Neuse* State Historic Site, and painstakingly preserved a late 19th-century galley stove. However, as is often the case at Fort Fisher, Nathan was pulled to more pressing activities which included salvaging a thirty-by-fifty-foot covered shed to be reconstructed and used as an artifact conservation and storage area, as well as helping construct the *Beauregard* Shipwreck Overlook Gazebo at Carolina Beach.

In addition to Nathan's many duties, he also participated in an underwater archaeological study of Civil War shipwrecks offshore of Fort Fisher as part of the National Park Service's American Battlefield Protection Program. Working with UAU staff members and ECU students under the direction of Billy Ray Morris and Marianne Franklin, detailed examinations were made of six shipwrecks. These included the blockade runners *Arabian*, *Condor*, and *Stormy Petrel*, the Union blockade vessel USS *Aster*, the former Army transport steamer *Flambeau*, lost after the war, and a shipwreck thought to be the USS *Louisiana*, but now suspected to be the *Twilight*, which sank in November 1865. The Fort Fisher project will provide research for several ECU theses and may eventually result in the formation of a North Carolina historic shipwreck preserve.

While managing the state's submerged cultural resources appears to be an overwhelming task, through cooperation with the ECU graduate program, Cape Fear Museum and other agencies, assistance from volunteers, and the dedication of staff members, the UAU is making strides toward the understanding, interpretation, and protection of North Carolina's rich maritime history.

Richard Lawrence is the Archeological supervisor with the Underwater Archaeology Unit, North Carolina Division of Archives and History.

Mark Wilde-Ramsing, is an archeologist with the Underwater Archaeology Unit, North Carolina Division of Archives and History.⚓

Marine Biology

Wetlands: Where Land Meets the Sea

Ramona Schreiber
National Marine Fisheries Service

When we think of a marine ecosystem, the first images that come to mind may be the blue ocean, beaches glistening with white sands, dolphins, and starfish. These differ considerably with our more familiar terrestrial ecosystem, including trees, soil, squirrels, and ourselves. Juxtaposed between the two, however, lies an ecosystem that is essential to both land and sea. This is the wetland habitat, where our terrestrial environment merges with the marine environ. In this article, we will take a look at the physical and biological composition of a wetland habitat, its value and vulnerability.

What are wetlands? The wetland habitat occurs in the transitional zone between permanently wet and generally dry environments. They are exposed to surface water flooding or high water tables that result in conditions to which animals and plants must adapt. These habitats possess an enormous range in diversity, according to origin; geographical location; water regime; chemistry; and plant, soil, and sedimentary characteristics. The constant mixing of salt and fresh water is representative of the mixing of marine and marsh phases. With this movement of tidal water across these habitats, fish move to wetlands and tidal marsh where they feed in freshly flooded areas. With the outward movement of the tide, birds, crabs, and other residents make use of the recently deposited creatures, including larval and juvenile fish and invertebrates, for a tasty feeding opportunity. The result of this ebb and flow is a complex system that remains in balance.

From a geologic perspective, wetlands often emanated in protected bays, like the Chesapeake Bay. They also developed behind offshore bars adjacent river deltas such as the Mississippi River. As sea levels began to rise, salt water cordgrass established in the intertidal zone. Many eastern wetlands are dominated by salt water cordgrass, as it is restricted to low marshes that are regularly flooded by tides. As sediment fills in behind the frontal zone of a wetland, the tall-growing salt water cordgrass is replaced by the shorter growing salt meadow cordgrass within the high marsh where flooding occurs only at high and spring tides. Across the southern coastal plain, tall growing black needle rush forms a second band and replaces salt water cordgrass. In southern California, this high marsh zone may contain pickerelweed and saltwort. And in the northeast, a third band may contain black grass adjacent the upland zone. Today wetlands occur throughout the world and across the United States coastline. While we will not discuss them here, freshwater wetlands are likewise found worldwide and offer additional diversity to the aquatic environment.

The ecological engineering within this ecosystem is complex. Its productivity is linked to freshwater flow from rivers. Lighter than the heavy, saline water that flows in from the coastal ocean, freshwater flows outward forming a surficial layer. This mechanism is called a salt wedge. It holds the nutrient rich waters of the estuary in place. Across the salinity gradient, nutrients cycle and recycle. All of this contributes to the higher layers of the food chain and eventually moves into the nearby coastal and open ocean environment.

The floral assemblages within wetlands exhibit a high degree of specialization. From a physiological standpoint, wetland vegetation must adapt to ranges of saline conditions. This is carried out through specialized structures called salt glands that assist in ridding excess salt from the plant. These are found in the leaves and stems of many plants. In comparison to terrestrial plants, these plants have porous tissue with intracellular spaces (called arenchyma) that allow growth in oxygen poor environments. In areas where oxygen is less available, other plants exist by converting nutrients to plant material without oxygen. These plants are able to accumulate ethyl alcohol during this process, a compound that is intolerable to most plants. The distribution of plants from the sea's edge landward occurs in an interesting banding pattern and correlates to the duration and frequency of flooding that occurs and the species' tolerancy to a saline environment. This lush wetland and marsh habitat provides far more than its natural beauty alone. Marsh vegetation that is not eaten by herbivorous predators provides essential detritus as matter sloughs from the plants into the aquatic ecosystem below. This detrital material is consumed, generally by invertebrates, or flushes into the water as dissolved or particulate organic matter. In this phase it provides a food source for estuarine organisms. This recycling of nutrients provides an essential engine that drives this ecosystem. On a much smaller scale, this environment houses microscopic plants—phytoplankton—within the aqueous environ. Together with zooplankton that make their home here, this microscopic material provides a conduit for energy to the next level in the food chain, as filter feeders such as oysters and clams consume these materials.

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Wetlands

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The fauna that reside within this habitat is as diverse as the flora. Moving up the food chain, juvenile fish like silversides feed on larvae and small invertebrates. Marsh and wetland frontal zones often are laden with mussels. These organisms play a crucial role in this dynamic habitat. Each extending a thread, the mussels offer a meshwork that holds together the saturated soil, thus reducing erosion. The mussels also concentrate nutrients within the system. Using their siphons to take in particulate matter, they release phosphorous, an important nutrient for plant growth, adjacent to the vegetation. Burrowing organisms like crabs and worms are essential to the aeration and drainage of the dense root systems. And this infusion of oxygen into the substrate accelerates decomposition of organic matter into usable nutrients within the food chain. Wetland and salt marsh also provide nursery habitat for many marine organisms. In fact, as much as 70% of the marine species rely on these habitats during their life history for refuge, feeding, or spawning. As young fish and shrimp develop, most will move to deeper waters upon maturity, where their energy is transferred again up the food chain through predation by larger fish species.

What are the values of these resources? Wetlands and similar coastal habitats serve several functions beyond biological support for marine biota. This ecosystem provides flood control, shoreline stabilization, and natural pollution control. Acting as a sponge, this habitat stores overland flow and slowly releases rain and runoff. As a result, flood peaks are minimized and the need for dams is reduced. Bank stabilization is likewise an economically important provision. Aquatic vegetation binds surficial sediments and reduces substrate loss to erosion and lowers the costs of sea wall defenses. Above ground plant material also assists in sedimentation and sediment accretion by trapping materials from upstream flows and enhancing sedimentation by slowing stream flow. This ecosystem enhances groundwater recharge as water moves through subsurface aquifers and into the earth's storage system and prevents saltwater intrusion into our water sources. Vital to habitat quality, wetlands serve a very important role in filtration of wastes and contaminants from the aquatic system. Many plants have been found to take up high concentration of contaminants, including heavy metals, industrial wastes, pesticides, and high nutrient concentrations. These toxic materials are moved through the plant and into the sediment where they are removed from the aquatic cycle. Likewise, they provide a sink for high nitrogen concentrations, thus preventing build-up and eutrophication. They provide a pathway for exchange of water, nutrients, organic matter, and biota, and provide the crucial links between estuaries, marshes, and open water. Fulfilling a myriad of roles to a multitude of flora and fauna, the value of these resources cannot be overestimated.

Our recognition of the numerous benefits of this resource has not always been the case. For decades we have developed these fragile areas for living space, dumped waste into its water, and blocked tidal exchange to benefit other resources at the expense of the natural wetlands. And as the desire to live near the water continues to grow, the pressures of urban expansion continue to play out on these fragile resources. It is up to us to respect these resources and gain awareness for their role in the entire ecosystem. We hope that we can retain those resources that remain, and restore those that have been damaged. As a result, the balance between ocean and land, plant and animal, humans' enjoyment and nature's business will be maintained.

Ramona Schreiber is a fisheries biologist for the Office of Habitat Protection, National Marine Fisheries Service, in Silver Spring, Maryland.⚓

Marine Facetiousness

Overcast: Not a sky in the clouds.

Polar Coordinates: Fashionable clothing worn by Eskimos.

High Seas Advisory: A wave review.

A Fog Forecast: What you can't see is what you get.

Marine Weather Forecaster: A person whom you can never depend upon to be always wrong.

Dense Fog: Mist defying.

Dense Fog with Drizzle: Abigamist.

Extremist: Dense fog.

Nautical Sunset: Deja view.

Moonlight: The sun's other job.

What do you get at the horse latitudes? Stable air.

Stormy Evening: A night-in-gale.

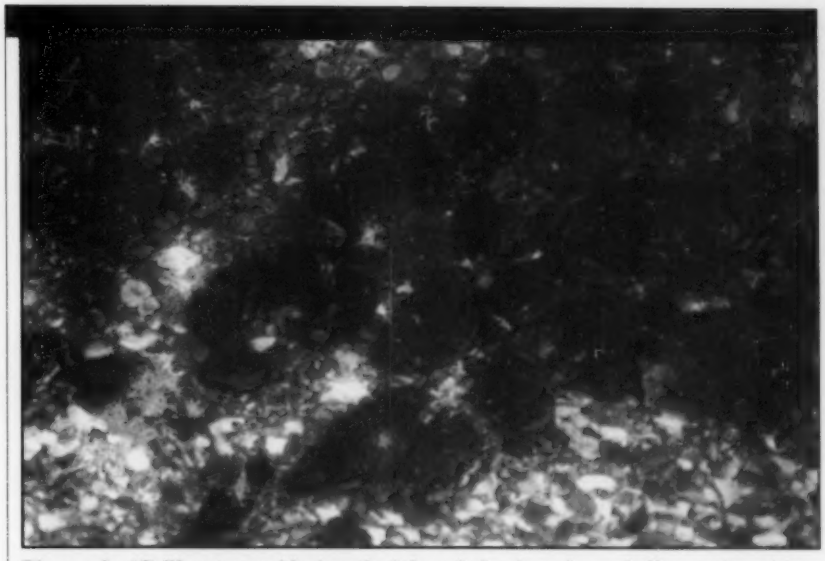
Becalmed is a no wind situation, while calm is just a nil wind.

Marine e x t e n d e d f o r e c a s t.

Courtesy of Bob Novak, PMO Oakland. Thanks, Bob!–ED.⚓

Coastal "Upwelling" in the Chesapeake Bay

Dr. Kent Mountford, Senior Scientist
U.S. Environmental Protection Agency
Chesapeake Bay Program



Blue crabs (Callinectes sapidus) packed densely in alongshore shallows attempt to escape low oxygen conditions that threaten their lives.

It was a brutal heat wave in the early 1980s. Washington, D.C., and its suburbs sweltered under a bronze disc of broiling hot sun. Air temperature and humidity day after day were in the 90s. Paul Freedman, President of a Michigan environmental consulting firm, was visiting from the Great Lakes, helping Washington-area scientists understand the massive pollutant-fed algae blooms which, that year, had painted the upper Potomac River a brilliant green.

We drove down the Chesapeake's western shoreline, south from Annapolis, Maryland, towards Solomons Island, which is about halfway between the Susquehanna River in Pennsylvania, which drains ten of thousands of square miles of watershed from Pennsylvania and New York state, and the Bay's confluence with the Atlantic Ocean, near the port of Norfolk in southern Virginia.

A hot wind, sweeping around that stagnant Bermuda high which all East Coast summer residents dread, had blown for several days. Previously, Paul had worked with us mostly in meeting rooms and over computer phone lines. Because he had never seen the Bay, I wanted him to appreciate her immense size and beauty, if only to spur him to greater efforts solving the problem we, the 14 million citizens of the watershed, have created since John Smith first explored these waters in 1607 and 1608.

We wound down a tree-lined country road to Flag Harbor, which occupies a valley piercing the high cliffs of Calvert. The cliffs stretch almost unbroken along 30 miles of the Bay's Western Shore. As we drove the last mile, I explained to Paul that from the top of Calvert Cliffs you could see almost 600 square miles of this, our Nation's largest estuary. From the beach at Flag Harbor, at one of the Bay's narrowest reaches, however, he'd be looking across only four miles of water to islands on Maryland's Eastern Shore.

In recent decades, the Chesapeake, I told him, was not noted for clear water during summer. Over the last half-century, pressures from increasing human population and development had clearly outstripped the Bay's ability to cope with incoming pollutants. The use of fertilizers and chemicals, fossil fuel use, and animal manure production had skyrocketed after World War II. The water in this hot summer weather, I expected, would be turbid and dark with billions of algae cells whose growth was spurred by the tremendous loads of nitrogen and phosphorus that resulted from man's use of this 64,000 square mile drainage basin.

The Bay was lit from behind us by afternoon sun as we swung down onto the beach and I was astounded to find the water uncharacteristically reflecting a blue as bright as any I'd seen in a half-dozen visits to the Caribbean. "That's really beautiful," Paul remarked.

I was dumfounded and mystified until we came close to the water. With the strong southwest wind at our backs, we saw the water was not actually clear, but white with countless billions of bacteria, the kind I was used to seeing in stagnant ponds where windows of the Bay's once abundant sea grasses were decomposing. These seemed to be the same sulfur bacteria, with the rotten-egg smell that signaled the disappearance of oxygen from the water.

Standing at the water's edge, we were even more astounded to see hundreds of the Chesapeake's blue-claw crabs packed together in only a few inches of water. "They're stacked like cars in a downtown DC parking lot!" Paul said. "Are they always like this?"

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Local residents eagerly harvest the unexpected largess provided by this "crab jubilee" event.

Coastal "Upwelling"

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"Never! ...at least not in the dozen years I've been here," I replied, but their behavior was beginning to make sense to my scientist's mind.

All along the shoreline ranging north of us to where the cliffs began, people were wading in the shallows, some with bushel baskets or picnic coolers floating beside them, busily scooping up these tasty crustaceans with crab nets. No doubt about it, this was one of the fabled "Crab Jubilees" when it seems like every crab in the Bay is trying to climb out of the water. As we moved along the beach, I counted crabs at a number of places just about a dozen feet offshore to where light reflection prevented me from seeing the bottom. I estimated that along the two miles of each in our field of vision there were hundreds of thousands of crabs directly offshore of the undertow. Just phenomenal!

And not only crabs. As we walked the water's edge, there were flounder, toadfish, white perch, and many of the small skilletfish and gobies that are part of the once abundant offshore oyster reef community, all lying torpid or fluttering in the few inches of water adjacent to the sand, some on their sides with one gill literally out of the water panting rhythmically. They were also in extremity starving for the oxygen which had been stripped from the Bay's deepest waters.

The story is a clear one to Chesapeake scientists. In Spring, when river flows are high, lighter, warmer fresh water overrides cold, heavier seawater that sweeps in from the Atlantic. The fresh water literally floats atop the salt and prevents most exchange or mixing between the two layers. With the gain or sensitivity turned up high, some depth sounding and fish-finding sonars can actually image the boundary between these two layers. Scientists call this discontinuity the "pycnocline" since it separates two vertical regions of differing temperature and salinity—and therefore density.

With the fresh water and its immense load of nutrients from man-generated activities in the basin, plankton blooms develop, growing literally millions of pounds of microscopic algae cells. When river flows decline late in Spring, the supply of nutrients dwindles and some of these algae die and sink to the bottom, with bacteria and decomposition consuming oxygen as they slowly fall through the water. Many of the algae are also eaten by other organisms and the bodily wastes of these myriad creatures follow the same path, consuming oxygen as they travel down in an organic submarine "rainfall."

With mixing between the surface and bottom layers severely restricted, this decline in oxygen not only persists, but intensifies. Billions of juvenile worms and clams which have grown during the previous fall, winter, and early spring, are condemned to death each year as oxygen drops to zero. Hydrogen sulfide is emitted from these now "anoxic" sediments and metal objects suspended in the overlying waters are subjected to severe chemically "reducing" conditions. Rusty iron turns coal-black and some metals like tarnished stainless steel are electrolytically "brightened" to shiny silver. These are severe conditions, hostile to almost all life forms. Through the summer, the entire deep water region of the Chesapeake Bay below 25-30 feet is denied as habitat to fish, shellfish, and the worms and crustaceans which are important to the Bay's food chain.

This would be bad enough if that were the extent of it, but enter "climate" and weather. In wet springs, when flow is inordinately high, both the stratification—the resistance of that pycnocline layer to mixing—and the sediment and nutrient loads pouring off the land are exaggerated. And in warm summers, the rate at which plankton and other organic matter decomposes and consumes oxygen is accelerated. Such summers usually

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Many crabs do not succeed in escaping low oxygen water which is brought inshore by "upwelling" during prolonged wind events.

Coastal "Upwelling"

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turn out to be ones where the anoxic zone (in which life is extinguished) spreads far south to the Rappahannock River in Virginia and intrudes into shallower waters and the Bay's tributary rivers.

In extremely hot weather, strong southwesterly wind flows cause a phenomenon similar to the "upwelling" which occurs along the world's continental shelves. Upwelling is associated with some of the world's major oceanographic phenomena, like the high productivity of coastal fisheries and "El Niño" events which can set off fishing industry catastrophes and shake national economies.

On the scale of the Chesapeake Bay, the effects we observed are no less dramatic. The wind literally blows warmer, lighter surface waters laterally across the Bay, piling them up against the opposite shore. The resulting imbalance starts a conveyor belt of deeper water flowing up from the Bay bottom into shallows on the up-wind (usually Western) shore. In this "upwelling," water oxygen is extremely low, or as we saw, wholly absent.

Between the 1950s and 1970s, when such events began occurring with greater frequency in the Bay, fishermen began complaining to scientists about finding crabs dead or lethargic in their box-like crab pots. As biologists took a closer look, it became clear the crabs were being killed or stressed by low oxygen in the bottom waters. The crabs were marine versions of the canaries used in 19th century coal mines. Because they were confined in the traps and unable to escape, they brought to the attention of unsuspecting humans that the Bay was under stress.

In recent years, scientists like Denise Breitburg at Philadelphia's Academy of Natural Sciences, have found that while some shellfish like oysters can close up and survive these low oxygen conditions for days at a time, small fish like the naked goby that defends its nest and eggs among the oyster shells, are driven away and their eggs die when bathed by intruding anoxic waters. Breitburg, scuba diving into these regions, has seen the bottom littered with scores of carcasses of fish of all kinds killed by lack of oxygen.

Oxygen deficit is not a problem unique to the Chesapeake. Crab "jubilees" like the one Paul and I saw are also seen on the Gulf of Mexico as well, and in 1978, an oxygen collapse, also driven by dying plankton, killed thousands of tons of sea life in the coastal ocean off New York Harbor. Oxygen in Western Long Island Sound in recent years has shown persistent summer declines which are viewed as a warning about pollution.

Actions by the state and federal partners in the Chesapeake Bay Program have reduced phosphorus entering the Bay significantly in the last decade. Farmers were being taught to attack nitrogen loads as well by fine-tuning fertilizer applications and good manure management. In addition, with new sewage treatment technologies, an increasing number of municipalities are removing a large proportion of both these nutrients. In Maryland's Patuxent River, just west of Flag Harbor, decreases in phosphorus and nitrogen are producing measurably better water quality—and higher oxygen on the bottom—for the estuary downstream.

What's the future? Environmental managers believe if, by the year 2000, we can reduce nutrient loads reaching the Bay by 40%, the Chesapeake's summer oxygen deficit can be reduced by about a fifth. This is, and will continue to be, a daunting task in the face of continued population growth and development, but success (reaching the 40 percent goal) ought to be reflected in better conditions for Bay life, including the valuable—and tasty—Blue Crab!

Dr. Mountford has worked on the Chesapeake Bay for 25 years. The Chesapeake Bay Program (1-800-YOUR-BAY) is a partnership of federal and state agencies (including EPA and NOAA) and citizen organizations, dedicated to restoring and protecting the Bay's living resources.⚓

Meteorology for Mariners

Pressure and Density in the Atmosphere and Ocean

Hans Rosendal, NWSFO
Honolulu, Hawaii

The atmosphere, at the bottom of which we live, is the envelope of air surrounding the Earth and held in place by gravity. Air is considered to be a fluid. By fluid we mean a substance, such as a liquid or gas, that is capable of flowing or readily changing its shape. A fluid exerts pressure in all directions, but the pressure is a function of the mass of fluid above a given surface. Pressure is measured in force per unit area. In other words, atmospheric pressure is a measure of the weight of the column of air above a point.

What we call air is a mixture of gases, mainly nitrogen (78%) and oxygen (21%), plus trace amounts of a few other gases, and variable amounts of water vapor in relatively small quantities. Because there is a constant number of molecules in a given volume of air, adding the water vapor molecules means that these lighter H_2O molecules will displace heavier nitrogen (N_2) and oxygen (O_2) molecules and the resultant mixture of gases will be lighter than dry air.

Air, unlike water, is a compressible fluid so the rate of pressure decreases as we move up in the atmosphere. This is not as simple as in water where pressure varies very simply with depth at a rate of one atmosphere of pressure per 33 feet or 10 meters of water. Thus the pressure measured at a depth of 50 meters of water would be 5 atmospheres of pressure due to the weight of the overlying water plus one atmosphere's pressure due to the weight of the air in the overlying atmosphere, for a total of 6 atmospheres of pressure.

In meteorology we use the unit of millibars for measuring pressure; where 1013 mb (or 1013 hPa) equals roughly one atmosphere's pressure. Atmospheric pressure is measured by a barometer. As mentioned earlier, the pressure of the atmosphere will balance about 33 feet (10 m) of water or 30 inches (76 cm) of mercury, which is much denser than water. The ratio of the densities of the two liquids, mercury to water, is about 13.6 to 1.

From the early days of meteorology, the relationship between atmospheric pressure and height above sea level has been studied very closely. The pioneering work by the French scientist Pascal is particularly important and that is why he is honored by the naming of the unit of pressure after him. The hectoPascal (100 Pascals) will soon be used worldwide by meteorologists instead of millibars. The early meteorologists or aviators ascended mountains or used balloons or aircraft to measure the change in pressure with height. Some rough standards were decided on, such as the 5,000 foot level for 850 mb, 10,000 ft for 700 mb, 500 mb at 18,000 ft, 250 mb at 34,000 ft, and 150 mb at 45,000 ft. Rocket scientists and space explorers also entered the picture in more recent times as knowledge about the outer fringes of the atmosphere became important.

The pressure in the atmosphere varies with the density and temperature of the air. There is a simple equation called the Equation of State that explains this relationship: $p = \rho * R * T$.

If we work with meters, tons, and seconds as basic units (the so-called m-t-s units of length, mass and time), then pressure must be given in centibars or kilopascals, where 1 cb=10 mb. If we plug in some numbers for sea level pressure of 100 cb and a density (ρ) of $1.2 * 10^{-3}$ tons/m^3 (1.2 kg/m^3), and a temperature of 27C=273+27=300K (Kelvin degrees), and the gas constant (R) of 278 kJ/t*K, we will find the equation in rough balance.

We can perform the same calculation for a point half way up in the atmosphere with respect to pressure at 500 mb or 50 cb. This is at a height of about 18,000 ft or 5.5 km where the temperature typically is -5C (268K). If we solve for density at that level, we arrive at $.67 * 10^{-3}$ tons/m^3, or roughly half the density of the air at sea level.

If we do the same calculation for a pressure of 250 mb, or 25 cb, and a typical temperature of -43C or 230K, we arrive at a value of density of air of $.39 * 10^{-3}$ t/m^3 or slightly more than half of the value we found at 500 mb. Two hundred and fifty mb is at a height of roughly 36,000 ft or 11 km, where modern jet aircraft fly. As we saw earlier, the standard height for the 250 mb pressure surface is closer to 34,000 ft, so we see our approach is only a rough approximation of conditions in the actual atmosphere.

Ascending another 18,000 feet, or 5.5 km, to 54,000 feet (16.5 km) we are at an elevation where the supersonic aircraft operate. We are now at a pressure of about 125 mb (12.5 cb) and a temperature of -65C (208K) and we find an air density of $.22 * 10^{-3}$t/m^3. Cutting the pressure in half once more at 62.5 mb, we find ourselves in the stratosphere at 22 km height where temperatures change very little with height and there may actually be some warming.

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Pressure and Density in the Atmosphere and Ocean

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There is another simple equation, the so-called Hydrostatic Equation, that relates changes in pressure to changes in height. This equation is: $\Delta p = \rho * g * \Delta z$ where Δp is the change in pressure and Δz is the corresponding change in height in m. As above, ρ is air density and g is gravity held constant at 9.8 m/s^2. If we want to make a quick calculation of what vertical distance in meters corresponds to a change in pressure of 1 millibar (0.1 cb) near sea level where the density is $1.2*10^{-3}$ t/m^3, we get the following result: 0.1 cb= - $1.2*10^{-3}$ t/m^3 * 9.8 m/s^2 * Δz. Solving for Δz, we get 8.5 m. In other words, a change in height of 8.5 meters near sea level, as you go up in the atmosphere, results in a reduction (thus the minus sign in equation above) in pressure of 1 millibar. If your location is 34 m (111 feet) above sea level you will have to add 4 mb to your barometric pressure reading to get an estimate of the sea level value. Thus relatively small changes in elevation show up on your barograph trace if you move the instrument as, for example, from the bridge down to a cabin on the lower deck. Likewise, the barogram from a ship entering the Great Lakes along the St. Lawrence Seaway as it moves from the St. Lawrence River to Lake Ontario via the locks at Massena and from Lake Ontario to Lake Erie via the Welland Canal will show the typical stairway steps as it moves up in the atmosphere within the locks. We are talking here about a change in elevation from sea level to the level of Lake Erie at 174 m above sea level or a reduction in pressure of about 20 mb.

At 500 mb we found out in our earlier computations that the density of air was roughly half of that at sea level, namely $0.67*10^{-3}$ t/m^3. We should therefore expect that the height difference (Δz) that corresponds to a 1 mb difference (Δp= .1 cb) in pressure at the 500 mb level, say going from 500 mb to 501 mb, will be roughly twice the height increments for the same pressure change at 1,000 mb. Plugging in the above values for density, we arrive at a value of 15.2 m. What all this tells us is that, as we ascend in the atmosphere, the pressure is roughly cut in half every 5.5 km or 18,000 feet. It is not an exact presentation of the variation in pressure with height since both density and temperature vary, but it is a rough approximation of the exponential loss of atmospheric mass or pressure with height shown in graphical form in Figure 2 (p.41). In comparison, the very simple variation of pressure with depth in the ocean is depicted in Figure 1.

The mariner cruises the ocean at the interface between the two fluids of air and water. As we have seen, water is about three orders of magnitude denser than air. By an order of magnitude we mean a factor of 10. Thus, one cubic meter of water weighs a ton or 1000 kg, while the same volume of air

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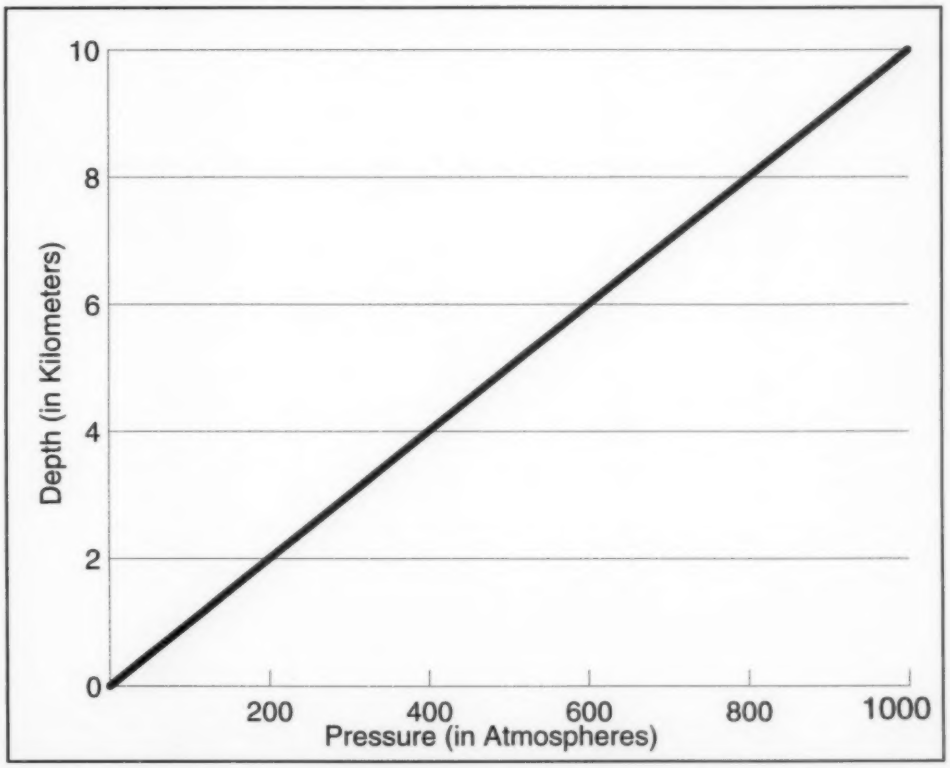

Figure 1. Pressure in the ocean varies linearly with depth. In the deepest trenches of the Pacific near the Philippines and Guam, the pressures reach about 1,000 atmospheres.

Pressure and Density in the Atmosphere and Ocean

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weighs 1.2 kg. Motions in the air in response to external forces are thus much swifter than in the oceans. Air currents, such as the jet streams up high in the atmosphere, may thus change their meandering paths in a matter of hours or days whereas similar drastic changes in the ocean will perhaps take years. The oceans have been referred to as the flywheels of climate due to the large inertia or resistance to change inherent in them.

Density differences in the ocean are minor as compared to the dramatic changes we experience in the atmosphere. Water, being a liquid, is not compressible, but it does expand and contract in volume slightly with changing temperatures. Small, but important density increases also occur with increases in salinity. The density of water thus varies only little, but these small variations are nevertheless very important because they determine how ocean currents flow and water circulates. We sometimes see these flows referred to as the thermo-haline circulations of the ocean.

These density differences also have some practical aspects to navigation. For instance, from the load lines painted on the side of the ship, we know that the depth at which a vessel is immersed into the water varies somewhat. The weight of the ship and its cargo displaces an equal weight of water. If the water is fresh and warm, the volume of this water will be larger, so the ship will be immersed deeper into the water. Thus, the tropical fresh water in the Panama Canal is somewhat less dense than the cold water in the North Atlantic in winter. So we see that temperature and salinity are the two determining factors. Cold water of high salinity is most dense and will tend to sink to the bottom of the ocean. The deep oceans therefore contain cold water that has been sinking in the North Atlantic and in the Antarctic from where it is spreading equatorward. The vertical stability of the ocean waters is smaller at high latitudes in winter as water masses move up and down or turn over more readily than at lower latitudes. These high latitude waters are well mixed so salinity differences in the vertical are relatively small in most parts of the world.

Ocean currents, besides being caused by wind stresses in the surface layers, are therefore nature's way of tending to even out these differences in density along a horizontal surface. The same laws of motion hold for the oceans as well as the atmosphere.

Ocean surface water temperatures vary between the freezing temperature of salt water (about minus 2C or 28F) along the fringes of the ice pack in polar regions and 30C (86F) in the warmer and more humid parts of the tropics. Salinity varies from brackish or almost fresh in some inlets and estuaries (and the Panama Canal) to the typical open ocean values of about 3.5% or 35 parts per thousand. Fresh water additionally has the important quality of being most dense at about 3.5 degrees Celsius. This means that fresh water lakes 'turn over' in cold climates and oxygen and nutrients are mixed throughout the volume.

Minor variations in the open ocean salinity values are caused by differences in evaporation and rainfall and outflow of fresh water from rivers. Highest salinity values are found in areas where evaporation greatly exceeds precipitation. These conditions occur underneath the atmospheric subtropical high pressure cells. The Mediterranean Sea and the Red Sea also qualify in this category. The Black Sea, while located in a climate of strong evaporation, experiences heavy runoff from land areas to cause local differences. High water densities due to very high salinity are of course found in the Caspian Sea, which is really a lake, as are the extreme cases of the Salton Sink of California and the Dead Sea of Israel/Jordan.

When fluids are in motion, we have transfer of momentum within a fluid, and we may experience transfers of momentum between different fluids. Transfers of momentum within the fluid of the atmosphere itself becomes more complex because we have a variation in density with height in air. On the other hand, density differences with increasing depth in the ocean, as we have seen, are small. By transfer of momentum we mean the product of mass times velocity. We are familiar with the concept in billiard balls or automobile collisions. In the case of air, we can use density of the air times its velocity. The usual case in the atmosphere is that we mix momentum downward from the fast flow aloft even though this fast flow consists of an air stream that is not nearly as dense as the air near the surface. In a mid-latitude storm or low pressure system, within the western semicircle of a storm we often find northwest winds of 160 kt at 250 mb height (35,000 ft) in the atmosphere near the jet stream level. At 500 mb winds are from the same direction at 80 kt, while at 1000 mb on the ocean's surface winds are northwest at 40 kt. Assuming density proportional to pressure, we find change in momentum with height is close to zero. In other words, as we descend in the atmosphere the wind speed diminishes at the same rate as the density increases. That is, we have the unique condition of a well mixed fluid in almost the entire depth of the atmosphere with no momentum transfers upward or downward.

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Ocean surface waves, also called gravity waves as gravity is the restoring force, are a manifestation of momentum transfers from the atmosphere to the ocean as the strong winds in a storm whip up large waves. The amplitude (height, or actually half of the height) of surface waves is relatively small (as gravity waves go) because we have large density differences (three orders of magnitude, as we saw earlier) between the two fluids of air and water. Internal waves in the ocean (or within the atmosphere, such as along an inversion) have small density differences across the surface along which these waves are generated and propagate. When talking about internal waves, we are therefore talking about relatively large amplitude waves that may be generated by a relatively slight force.

The case of a ship experiencing 'dead water' may be a manifestation of how the energy of propulsion of a ship is diverted into the development of internal waves in the ocean. The density differences across the surface, along which these internal waves travel, may in this case be caused by a shallow layer of warmer or fresher water overlying colder more saline water.

There are many other interesting aspects of the changes in pressure and density in the atmosphere and the ocean. The temporal and spatial changes in temperature, as we have seen, are other important factors to consider. In the atmosphere, consisting of air which is compressible, temperature takes on a entirely new meaning. That is, as air moves downward in the atmosphere it moves into regions of higher pressures and will be compressed which will result in warming. The opposite effect of cooling occurs as air rises and expands at the lower pressures aloft. Then we also have the complicating factors of water vapor and the change of phase between the gaseous, liquid, and solid states of water. Likewise, in the oceans, we have the complicating factors of varying salinity. There is, therefore, much more to discuss in following articles.⚓

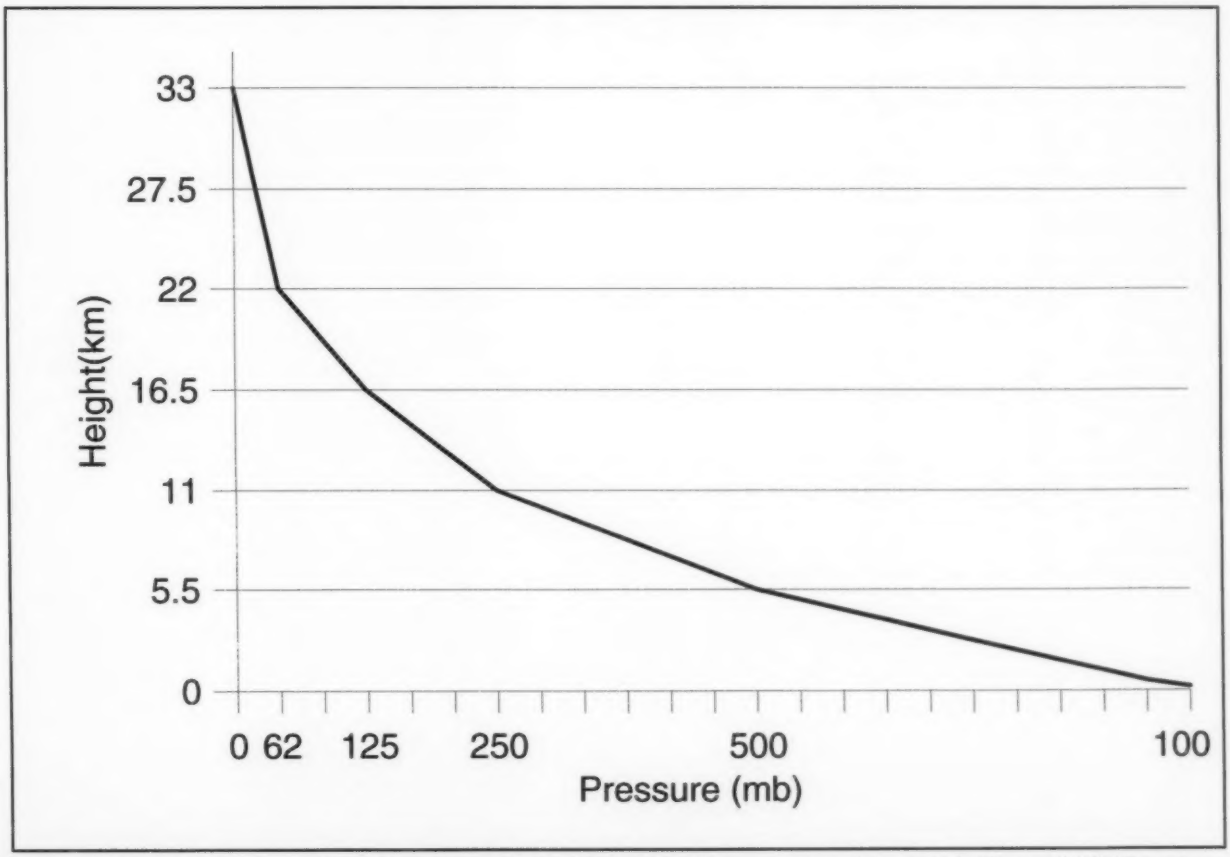

Figure 2. Atmospheric pressure diminishes exponentially with height with pressure roughtly cut in half every 5-1/2 kilometers.

HURRICANE WARNING

Hurricane Warning: Where Will Your Boat Be Safe?

Debi Iacovelli

Imagine that you have just heard that an intense hurricane was off the coast heading for your area. As you rush to the marina (or your dock) to inspect your boat, what will your plan of action be to ensure that your boat will survive the storm?

The procedure of securing your boat against the intense winds and waves of a hurricane requires extraordinary effort on your part. During hurricane season things can happen quickly. If a hurricane is headed toward your area, you may not have a lot of advance notice. It's wise to formulate an intelligent plan of action now, while you still have the time.

The safest place for your boat is far inland, away from the high winds and hurricane storm surge (wind-driven tidal surge). But if that's not a reality, what can you do? Let's examine a few possibilities:

At Your Dock

Many people want to keep their boats at their homes and tied to their docks during a hurricane. But this is not necessarily the safest place, as boats sometimes wind up underneath, on top of, or sunk under the dock after a storm. If the dock (fixed or floating) has sturdy pilings and is well-sheltered from open waters, it may offer some degree of protection.

At a Marina

You should not trust hurricane preparation of your boat to the marina owners or operators. They may be quite busy, and would not care for it with the same interest that you would. Now is the time to discuss your concerns with the marina and get an idea of the plans they have in case of a hurricane.

At a Mooring, Anchor, or Both

To moor or anchor your boat in open water or a harbor that isn't too crowded is a good bet, especially since the boat can swing and face the wind, thus reducing windage. The chance of your boat dragging the mooring can be reduced by inspecting its condition and using two storm anchors. A third anchor can be used in place of the mooring. Three anchors set 120 degrees apart allows the boat to swing into the wind. It is important to have a lot of heavy, oversized chain and plenty of scope — at a ratio of at least 10:1. The scope can be increased by lengthening the mooring pennant. Also, placing a weight (or sentinel) at the nylon/chain juncture will reduce strain on the boat by lowering the angle of pull on the anchor.

Embedment anchors far exceed the holding strength of the mushroom or deadweight anchor. Embedment anchors are screwed into the bottom and can withstand anywhere from 12,000 to 35,000 pounds of pull. A mooring company in Vermont is making an oversized bungee-style mooring system that will stretch during high winds and seas, reducing the forces on the deck, pennant, or mooring hardware. These polyurethane elastic rodes can stretch up to four times their unloaded length, keeping the boat pointed into the wind, rather than yawing.

Hurricane Hole

This is a deep and narrow area, inland far enough from high coastal winds and storm surge and surrounded by young, sturdy trees than you can reach within an hour's drive. You can start by asking members of your local Coast Guard or Power Squadron where the best hurricane holes are located. Use two anchors in the water and two lines tied to small trees on land for one possible arrangement.

Storage Ashore

If your boat is small, has low freeboard, or can be trailered, it is safer stored ashore if you can find a sturdy building to store it in. A boat onshore creates more windage than if it were in the water, especially deep-keel sailboats. But, with any boat, a cradle offers more protection than a jackstand.

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Hurricane Warning

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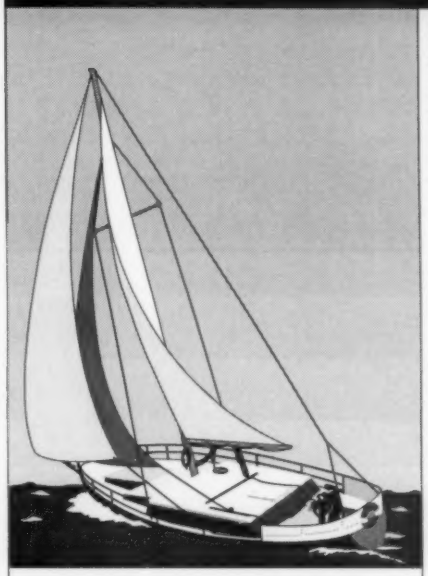
Now is the time to inspect the condition of your trailer. If you have two flat tires you will not be able to move your boat far inland, away from a damaging hurricane. If possible, and if the boat is the right size, store it in your home garage in place of your car, since the boat is lighter and would be more vulnerable to hurricane winds. If this isn't feasible, let the air out of trailer tires and leave the drain plug in (except for inboard boats), adding water with a garden hose. Place wood blocks between the trailer's frame and springs to support the increased weight. Lash the boat to the trailer and secure the trailer to trees, or anchor it to the ground. Remember to strip the boat of all loose items.

Additional Points to Remember

A second set of docklines (nylon, because it absorbs shock) should be used to secure your boat if it is to remain in the water. Make sure this second line is at least a size larger than the one you are already using. The longer the docklines, the better a boat will be at coping with the storm surge during a hurricane.

Chafe protectors should be on all lines at the chocks and other chafe points on the boat. You can either purchase chafe protectors or make your own using neoprene hose or heavy canvas. For maximum protection (and if your chocks are large enough), fit a second, larger-diameter hose around another hose that fits snugly around the line. Drill holes in both hoses and use cord to tie them securely to the dockline. For quick protection, use duct tape to



secure several layers of canvas to the lines. If you have the time, it's always better to sew the canvas rather than use tape.

Also, check the condition of your cleats and chocks. Using 2 sets of docklines may cause a problem if they are in bad condition. If necessary, add more and larger cleats and chocks now, making sure they are backed properly with stainless steel or aluminum plates, or at least large diameter washers. Don't lead too many lines to the same cleat. Don't tie lines perpendicular to the cleat's base. Four-hole cleats are stronger than the two-hole cleats.

Before you leave the boat, strip all loose gear including bimini tops, antennas, canvas covers, anchors, outriggers, life rings, dinghies, running rigging, etc., to cut down on windage. Anything that can't be taken off deck should be secured. Don't forget to remove cowl ventilators and seal the openings.

Sails should be removed, as they almost always unfurl, no matter how securely they are tied. Halyards should be run to the masthead and secured with a single line led to the rail. Take off all electronics — not only because of possible damage, but also in case of vandalism. Use duct tape around ports, hatches, lockers, etc., to prevent water seepage into the cabin.

Close all drain seacocks except for the cockpit, and bang a plug into the engine's exhaust pipe to prevent water from getting into engine cylinders.

It's nice to have someone who is familiar with your plans to secure your boat in case you are ill or out of town during a hurricane warning. If possible, make them a set of keys for the boat, and rehearse your plan with them at the beginning of hurricane season.

For further information about boating preparedness, please call your local Coast Guard or Power Squadron.

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Voluntary Observing Ship Program

Martin S. Baron
National Weather Service

Hurricane Season Reminder

Please remember to report weather once every three hours when within 300 miles of named tropical storms or hurricanes. This is a standard World Meteorological Organization policy for all Voluntary Observing Ships (VOS). The additional 3-hourly data helps the meteorologist monitor the development and movement of these dangerous storms. The northern hemisphere hurricane season runs from June through November. Be very cautious and alert during this period, and closely monitor weather broadcasts, storm watches, and warnings.

Importance of Ship Reports In Forecasting

Ship report data are of tremendous value to forecasters. Marine forecast operations, particularly at the national prediction centers (Marine Prediction Center and Tropical Prediction Center), would be critically impaired without ship reports. These reports provide information about the actual local weather and sea conditions in your area of operation, which is usually not available otherwise. They are used to determine the strength and intensity of weather systems, including tropical and extra-tropical storms (mid-latitude cyclones). They are also used in forecast verifications—as truth data to determine if past forecasts were on the mark.

All of the elements of the ships synoptic code (24 code groups including the BBXX ship report indicator) are important, and you are requested to include all of them in the weather message. Of course, if you are not reporting data such as ice or very high speed wind, these groups should be omitted. Groups are omitted by skipping over them—please do not report a group as /////.

Is there a single most important weather element to observe and report? Most meteorologists will agree that pressure, temperature, and wind are the primary elements of your report, and are most important for meteorological analysis. Your atmospheric pressure reading is probably the most critical element most of the time, and this is why the PMO makes a bee-line for your ships barometer during each ship visit (to check the posted correction to sea level, calibrate the barometer, or change the correction, if necessary). Your pressure reading must be very accurate, because the meteorologist uses it to draw isobars (lines of equal barometric pressure) on the surface weather chart. The locations of fronts, storms, highs, and lows can then be pinpointed and drawn on the chart. If your pressure reading is off by as little as 1 hectopascal or millibar, it will cause problems for the analyst. Without pressure data from moving ships, production of the surface analysis, the most fundamental meteorological analysis, would not be possible over vast expanses of ocean.

But the other data are very important as well, and in most cases, are the only data to go by. For example, if ships did not provide swell observations, there would be no swell data at all! Over the high seas, the meteorologist is completely dependent on ship data—without it, there are no surface data. Please remember this when preparing your report, and provide data that are as complete and accurate as possible.

The Role of The PMO

Mariners customarily welcome the PMO as a trusted friend providing a vital service. What is the role of the PMO, and how important is it?

Port Meteorological Officers spend most of their time visiting ships in support of the VOS program. This is to recruit and maintain ships as voluntary weather observers. As already explained, this is a very important support function, because ships are the only source of surface meteorological data from most of the vast marine areas of the globe. Day-in and day-out, PMOs are on the waterfront, beating the turf, visiting ships. In some major United States ports, the PMO will perform over 30 ship visitations each week.

It's a demanding, multifaceted assignment. The PMO provides ships' officers with technical information about observing, coding, and report transmission procedures, often providing individualized one-on-one instruction. The PMO installs and calibrates shipboard instrumentation, provides observing forms, technical aids, and supplies. There is interaction with ships' officers of diverse nationalities. Because of the very tight schedules maintained by ships in port, the PMO must carefully plan the time of the ship visit, or the ship will have departed by the time he arrives. Because port facilities are frequently spread out over many miles of waterfront, the PMO spends much time driving to and from the ships. As you are well aware, the PMO must be very careful in the dockside cargo transfer areas—these areas can be very hazardous, especially when cargo is being moved. This cargo transfer period is usually the only time when the PMO is able to

Continued on Page 45

Voluntary Observing Ship Program

Continued from Page 44

perform his visitation service, just before the vessel departs the port.

Vessels have frequent changes in ships' officers, routes, agents, and ownership. The PMO must keep up with these changes, because of the impact they have on the ships' participation in the VOS program and the quality of the observations.

The VOS program is an international endeavor involving over 7,000 ships from nearly 60 nations. PMOs provide service to vessels regardless of their nation of registry or national affiliation.

This international element gives the VOS program a special dimension, adding to the uniqueness of the PMO position. PMO visits to foreign program vessels are known as "courtesy" visits. In contrast, PMO visits to vessels in the United States program are considered "Program" visits. Courtesy visits to foreign vessels are just as important as visits to program ships—the marine data acquisition effort is multinational and worldwide in scope, and the PMO is the key player ensuring it's success.

NWS PMOs keep track of ship visits by recording them in a national computer database. This database currently contains a record of all PMO ship visits going back over 15 years.

The World Meteorological Organization (WMO) publishes detailed guidelines on how PMO activities should be organized for the shipping community. These are contained within the WMO Guide to Marine Meteorological Services, WMO-#471, Part II, Annex II-1.H.

Please appreciate the complexity of the PMO's assignment, and cooperate in every way possible. See the back of this publication for a complete list of NWS PMOs. Contact any one of them for assistance.

Marty Bonk Retires; Pete Gibino Transfers to Norfolk

Marty Bonk, PMO Norfolk, retired July 31, 1996, after 37 years of government service, 31 years with the Navy, and 6 years with the National Weather Service. He was a PMO for 4½ years, first in Newark, New Jersey, from 1991 to 1994, and then in Norfolk. He is moving to St. Marys, Georgia (about 50 miles north of Jacksonville, Florida), where he will be selling real estate. His home address will be 507 Elbow Lane, St. Marys, GA 31558.

Pete Gibino, who has been serving as PMO New York, will take Marty's place, to become the PMO in Norfolk. This creates a vacancy for the New York position.

New Recruits

April - June 1996

During the 3-month period ended June 30, 1996, PMOs recruited 74 vessels as weather observers/reporters in the National Weather Service VOS Program (see page 49). Thank you for joining the program.

When observing and recording data, always be very careful and meticulous. An inaccurate observation can be very misleading to the forecaster. Please follow the worldwide weather reporting schedule as best you can—report weather four times daily at 0000, 0600, 1200, and 1800 ZULU or UTC time. The United States and Canada have a 3-hourly weather reporting schedule from coastal waters out 200 miles from shore, and from anywhere on the Great Lakes. From these coastal areas, please report weather at 0000, 0300, 0600, 0900, 1200, 1500, 1800, and 2100 ZULU or UTC, whenever possible.

To transmit your weather report to the NWS, use:

(1) INMARSAT Standard A or Standard C

(2) U.S. Coast Guard SImplex Teletype Over Radio (SITOR), or plain language (recite the coded message using radiotelephone)

(3) Commercially operated shore radio stations (using SITOR or CW), as a back-up, if methods (1) or (2) are not available

See Chapter 3 of the new NWS Observing Handbook No.1 for more details about transmitting your weather reports.

Meteorological equipment supplied to vessels—barometers, barographs, sling Psychrometers, wind wheels, and sea-water bucket thermometers are **loaned** to vessels taking weather observations. If, for any reason, your vessel's participation in the VOS program should discontinue, equipment must be returned. Equipment is expensive, and supplies are very limited. Please help ensure that equipment is accounted for and available for new recruits.⚓

The Yuriy Ostrovskiy *was one of the ships recognized in 1995 by the VOS program. Standing left to right are Second Mate Durnovskiy Vyacheslav, Seattle PMO Pat Brandow, Captain Sidorov Vladimir, Third Mate Svyatik Dmitriy, and Radio Officer Kravchenko Nikolay.*

A 1995 VOS plaque was awarded to the Westwood Anette *for the high quality of surface observations. Pictured with PMO Pat Brandow of Seattle from the left are Captain Ronelo Ledesma and Radio Officer Edgar Javison.*

Steve Kuhl, Meteorologist-in-Charge at the National Weather Service Office in Kodiak, Alaska, presented a NOAA/NWS plaque to the captain and crew of the United States Coast Guard Cutter Storis *(WMEC-38) on December 14, 1995. The plaque was presented to the* Storis *in recognition of her outstanding contribution to the NWS VOS program while operating in the Bering Sea during the Winter of 1994. The plaque was received by Captain Jerry Davis, Commanding Officer of the* Storis, *while several officers, crew members, and a representative of the United States Coast Guard, Office of Public Affairs looked on. Captain Davis was grateful for the recognition, and looks forward to continued cooperation between the National Weather Service and the Coast Guard in the future. Captain Davis also extended his wholehearted appreciation to the National Weather Service, for its invaluable service to the Coast Guard, and all mariners, through the Marine Facsimile Program.*

The Edelweiss *comes through with one of the top honors for 1995 in the VOS awards program. Seattle PMO Pat Brandow on left, Captain I.S. Razack, and Second Officer Lin Shao Min.*

PMO Larry Cain presented a 1995 VOS award to S/S Guayama *moored at Blount Island Marine Terminal, Jacksonville, Florida. Pictured from left to right are 3rd Mate Richard Wickenden, Captain Steve Hewitt, and Cadet Wil Hendricks.*

New Orleans PMO Jack Warrelmann presents a VOS award to Captain Doug Izatt of the vessel Acadia Forest.

New Orleans PMO Jack Warrelmann present a VOS award to Captain William L. Dunford of the vessel Robert E. Lee.

Federico V. Jiminez of the M/V Sven Oltmann *was recently awarded a VOS plaque by PMO Charles Henson of Port Everglades, Florida. The* Sven Oltmann *runs routinely between the Caribbean, Northern South America, and Florida.*

PMO Charles Henson of Port Everglades, Florida, presented a VOS plaque to the M/V Arktis Light. *From left to right are: Chief Mate, Second Mate, and Captain of the* M/V Arktis Light.

Captain G.J. Tuinstra of the Nedlloyd Van Noort, *displays an NOS Certificate of Appreciation presented to him on behalf of the NOS SEAS program by Los Angeles PMO Bob Webster.*

Charles Henson, PMO in Los Angeles, recently presented a VOS award to the M/V Senator. *Left to right are Chief Engineer Charles Russell, Captain John McFadden, and Training Cadet Patrick Nolan. Super crew and a tremendous asset to the program!*

National Weather Service Voluntary Observing Ship Program

New Recruits from 01-APR-96 to 30-JUN-96

NAME OF SHIP	CALL	AGENT NAME	RECRUITING PMO
AMBASSADOR BRIDGE	3ETH9	K-LINE AMERICA INC	SAN FRANCISCO, CA
ASPHALT COMMANDER	WFJN	SARGEANT MARINE, INC.	NEW ORLEANS, LA
ATLANTIC	3FYT	HOME LINES	MIAMI, FL
AUSTRAL RAINBOW	WEZP	MASTER	NEW ORLEANS, LA
BELGIAN REEFER	OXKL4	J. LAURITZEN A/S	BALTIMORE, MD
BOHINJ	V2SG	GENERAL STEAM SHIP	SAN FRANCISCO, CA
BRIGHT PHOENIX	DXNG	VICTORIA SHIP MANG., INC. 1ST FLR.UCHIDA-YOKO	SEATTLE, WA
BUNGA ORKID DUA	9MBQ4	MAYAYSIAN INTERNATIONAL SHIPPING	SEATTLE, WA
CAROLA E	P3FK4	INCHCAPE SHIPPING	MIAMI, FL
CHUN HO	3FAF6	TA-HO MARITIME CORP.	SEATTLE, WA
COLUMBUS AMERICA	ELSX2	COLUMBUS LINE INC.	NORFOLK, VA
CONFIDENCE	9VXH	WALLEM SHIPMANAGEMENT LTD., 46F HOPEWELL CTR	NEW YORK CITY, NY
COPACABANA	PPXI	ALIANCA	NORFOLK, VA
CSAV RUNGUE	DGRN	CHILEAN LINE INC.	NEWARK, NJ
DESTINY	3FKZ3	CARNIVAL CRUISE LINE	MIAMI, FL
DORTHE OLDENDORFF	ELQJ6	EGON OLDENDORFF	SEATTLE, WA
ELLIOTT BAY	DZFF	NISSEN KAIUN CO., LTD	SEATTLE, WA
FIGARO	SIRA	WALLENIUS LINES (NORTH AMERICA) INC	NEWARK, NJ
FROTA BELEM	PPOA	OMNIUM AGENCIES, INC	NEW YORK CITY, NY
GOLDEN BEAR	NMRY	CAPTAIN GOLDEN BEAR, U. CAL STATE MARTIME ACAD	SAN FRANCISCO, CA
GOLDEN FAN	3EIK4	"K" LINE AMERICA INC	NEW YORK CITY, NY
GYN YOH	DZOF	MMS CO., LTD. SURFELL NAKAMEGURO BLDG.	SEATTLE, WA
GYPSUM KING	ZCAN2	UNITED STATES GYPSUM CO.	MIAMI, FL
HANJIN HOUSTON	DSEC4	HANJIN SHIPPING CO., 20TH FLOOR, MARINE CTR BLDG	SEATTLE, WA
HANJIN PORTLAND	3FSB3	HANJIN SHIPPING	NEWARK, NJ
HARMONY	3FDB4	VERMILION OVERSEAS MANAGEMENT CO. LTD.	BALTIMORE, MD
INLAND SEAS	WCJ6214	INLAND SEAS EDUCATION ASSOCIATION	CHICAGO, IL
ISLAND BREEZE	C6KP	CARNIVAL CRUISE LINE	MIAMI, FL
JADE ORIENT	ELRY6	LASCO SHIPPING CO.	SEATTLE, WA
KIOWA	ZCBD6	RICE, UNRUH & REYNOLDS CO.	NEW YORK CITY, NY
KISHORE	ATMC	WEAVER MARINE AGENCIES, LTD	NEW YORK CITY, NY
KOMET	V2SA	GLOBE SHIP MGMNT.	MIAMI, FL
MAERSK SOMERSET	MQVF8	MAERSK COMPANY LTD.	NEW ORLEANS, LA
MARCARRIER	V2VM	SCHIFAHRTSGESELLSCHAFT MBH & CO. KG	NEWARK, NJ
MING ASIA	BDEA	YANGMING SHIPPING	NEWARK, NJ
MOUNTAIN LADY	ELQK2	WEAVER MARINE	NEW YORK CITY, NY
NELVANA	YJWZ7	SPARROWS POINT SHIP AGENCY, LTD	BALTIMORE, MD
NEPTUNE ALDEBARAN	S6EF	NEPTUNE SHIP MANG., SVC.	SEATTLE, WA
NEPTUNE ALTAIR	9VGE	NEPTUNE SHIPMANG. SERVICE, LTD	SEATTLE, WA
NOAA SHIP KA'IMIMOANA	WTEU	NOAA HONOLULU PORT CAPTAIN	SEATTLE, WA
NORTH EMPRESS	ZHEH4	NORTH EMPRESS SHIPPING CO., LTD	MIAMI, FL
NOSAC GALAXY	VRUI2	STEVENS SHIPPING & TERMINAL CO	JACKSONVILLE, FL
NOSAC TANABATA	ELQQ8	BARBER SHIP MANAGEMENT	BALTIMORE, MD
OBO BASAK	TCQB	MARTI DENIZCILIK VE TICARET A.S., KILICALI PASA	NORFOLK, VA
OCEAN GREAT	DUBG	SHOEI KISEN KAISHA, LTD	SEATTLE, WA
OCEAN PRIZE	DVCI	MARINE ENGINEERING CORP, 4TH FL, OKAJIMA BLDG	NEWARK, NJ
OCEAN STAR	WBD4963		BALTIMORE, MD
OOCL CHINA	ELSU8	OOCL (USA) INC.	LOS ANGELES, CA
OOCL HONG KONG	VRVA5	OOCL (USA) INC.	SAN FRANCISCO, CA
ORIENTE GRACE	3FHT4	RAINBOW MARITIME CO., LTD	SEATTLE, WA
PACIFIC HOPE	DVDB	CHO YANG SHIPPING CO. LTD	SEATTLE, WA
PACTOL RIVER	ELOT2	RUGGERIO & OGLE	NEW YORK CITY, NY
PINO GLORIA	3EZW7	SEADOG SHIPPING S.A., UNIICHI9 BLDG 6 FLR	SEATTLE, WA
RO RO SARAWAK	S6DL		MIAMI, FL
ROGER REVELLE	KAOU	NIMITZ MARINE FACILITY	NEW ORLEANS, LA
SAGA CREST	LATH4	DENHOLM SHIP MGMT. (O) LTD.	MIAMI, FL
SAQQARA	SUAF	MISR SHIPPING CO.	SEATTLE, WA
SARAMATI	9VIW	EASWIND SHIP MANAGEMENT PTE. LTD.	BALTIMORE, MD
SEA-LAND COLOMBIA	V2MC	SEALAND SERVICESME	MIAMI, FL
SEACHAMPION	DYGS	ANGLO EASTERN SHIP MANG., LTD	SEATTLE, WA
SININNI	ELME4	BILL BLACK AGENCY	NEW YORK CITY, NY
SIRIUS I	C6NL3	BILL BALACK AGENCY - NEW YORK	NEW YORK CITY, NY
SONG OF NORWAY	LNVP	ROYAL CARRIBBEAN CRUISE LINE	MIAMI, FL
SPAR EIGHT	DVYE	FAIRMONT SHIPPING CANADA	MIAMI, FL
SS SLURPEE	UBET	DIMITRI CHAPPAS	MIAMI, FL
STOLT TAURUS	ELIZ6	SAGA USA	NEW YORK CITY, NY
STOLT TENACITY	D5CP	SAGA (USA) INC.	NEW YORK CITY, NY
STOLT VINLAND	ELOR5	SAGA (USA) INC	NEW YORK CITY, NY
TOYOSHIMA MARU	9VND	IINO MARINE SERVICE CO., LTD	SEATTLE, WA
TRENT	ELSM2	OMI CORPORATION	NEW YORK CITY, NY
TURMOIL	9VGL	J.F.MORAN COMPANY	NEW YORK CITY, NY
USNS LARAMIE T-AO 203	NLAR	MASTER	NEW ORLEANS, LA
WORLD TRADER	DXOO	MMS CO., LTD, SURFEEL NAKAMEGURO BLDG	SEATTLE, WA
ZIM MONTEVIDEO	V2AG7	CAPES SHIPPING AGENCIES	NORFOLK, VA

A Familiarization Float Aboard the U.S. Coast Guard Cutter Firebush on October 27, 1995

Stephan C. Kuhl
Meteorologist-In-Charge
National Weather Service Office
Kodiak, Alaska

As part of my Port Meteorological Officer duties I was requested to bring updated National Weather Service (NWS) Marine Weather Services Maps Alaskan Waters (MSC-15) to the United States Coast Guard Cutter (USCGC) Firebush and calibrate the ship's barometer. At 10 am on October 26, 1995, I arrived at the ship's Quarterdeck and was welcomed aboard by Chief Paul Webb. After completing the barometer calibration, I asked Chief Webb if I could sail aboard the Firebush on a familiarization float to observe what kind of work the USCG does and to see first hand their operations. Chief Webb immediately cleared my request with the commanding officer of the Firebush, Captain Craig Gilbert, and I was invited to sail with them the following day.

I arrived at the Firebush on October 27th at 8 am. Chief Webb was again there to welcome me aboard. The ship left port at 8:30 am and sailed east to Chiniak Point, Alaska. At 10 am the Firebush launched a small boat ashore with about a half dozen crewmen. The small boat contained several batteries and a new light which needed to be installed in a navigation light located at Chiniak Point. While the small boat was out servicing the Chiniak light, the Firebush was busy running 24 different compass courses so Chief Webb could calibrate the ship's main compass. These operations provided me with an excellent experience to see first hand how the USCG operates. Overall, I was very impressed by the crew's professionalism and how well they navigated the ship.

During my trip I was on the bridge most of the time, except for when I went to the ship's radio room to observe the ship's marine fax printer and when I ate lunch. I had lunch with the Captain and some of the other officers. The clam chowder soup, baked cod, potatoes au gratin, and spinach salad were delicious.

Although the weather was clear with unlimited visibility, Captain Gilbert had the crew return to their home port with a simulated near zero visibility fog exercise. It was impressive to see how the navigator, ship bearing takers, helmsman, Captain, and everyone else on the bridge worked together to bring the ship into port under these simulated zero visibility fog conditions. We returned to the USCG Integrated Command Center Kodiak at 3:30 pm. Upon our arrival, Captain Gilbert asked me if I could return to the ship to provide training on how to interpret the marine fax charts that are transmitted daily via the WSO Kodiak NOJ marine fax program. I agreed with Captain Gilbert that this would be beneficial for both the NWS and the

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Bob Webster, PMO in Los Angeles, presents a VOS award to Maui *Chief Officer Marty Paige. The* Maui, *a Matson Line ship, operates between the U.S. west coast and Hawaii.*

Captain V. Richter of the MV Almania *proudly displays his ship's VOS award.*

Fam Float

Continued from Page 50

USCG, and the Captain said he would call me to set up a date. Upon returning to WSO Kodiak and explaining to the staff how my trip went, Jim Peronto, meteorologist intern, expressed great interest in accompanying me when I return to the Firebush to provide marine fax training. Jim and I put together a 2-hour comprehensive marine fax training program and presented it to the Captain and the crew of the Firebush on December 12, 1995.

Overall, my experience aboard the Firebush was very interesting as well as highly educational. It gave me a clear understanding of the importance of producing accurate and timely NWS marine products and services, which are used by the crews of ships such as the Firebush on a daily basis. I recommend that anyone who has the opportunity to take a familiarization float aboard a USCG Cutter should do so. My first trip aboard the USCGC Firebush was a great experience and I felt I might share it with you.⚓

BBXX and AMVER Work Together

Chris Noe, National Ocean Service

NOAA has released a new version of the Shipboard Environmental (Data) Acquisition System (SEAS) software for use by Voluntary Observing Ships (VOS). This software will allow mates on the bridge of commercial vessels to enter their BBXX messages into a personal computer (PC). The computer performs a series of quality control checks to ensure that the observations are correct and then formats the message for transmission by INMARSAT Standard C.

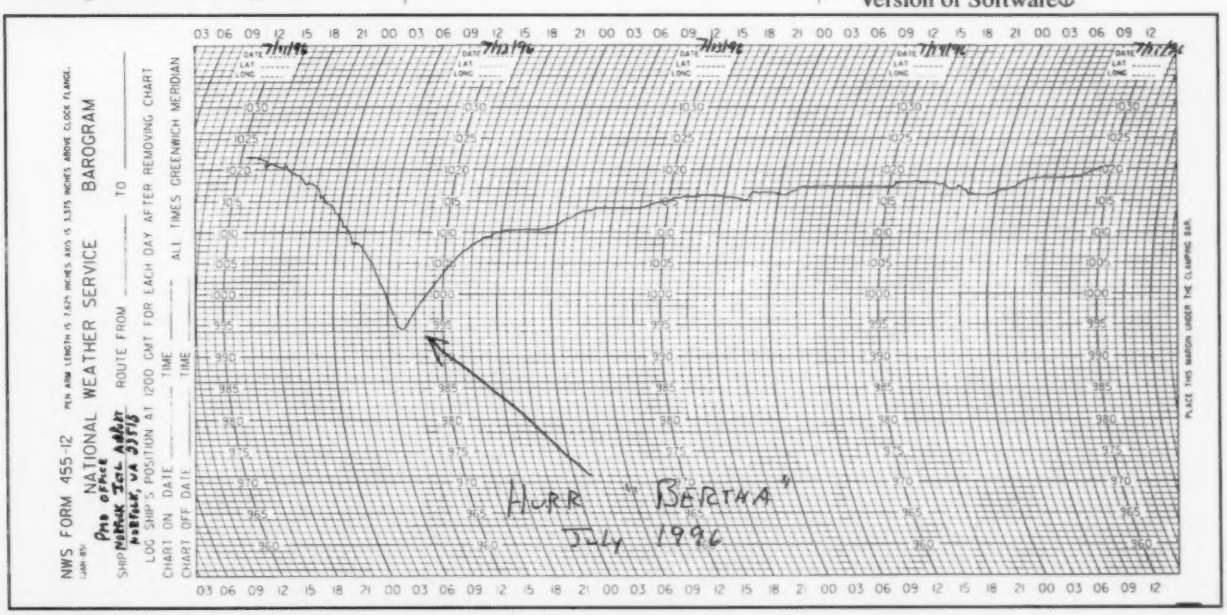
This software also supports the Automated Mutual-assistance VEssel Reporting system (AMVER). Once a Sail Plan is entered and stored on the PC, subsequent plans can be created by reading in the old plan and just updating the departure date and time. The way points and arrival times are updated automatically. Then, if BBXX messages are sent as described above, ships can avoid sending in separate position reports because the ship's position is part of the BBXX message. Each BBXX message is converted by NOAA into a properly formatted AMVER Position Report and forwarded to the Coast Guard within minutes of receipt. Ships participating in AMVER and using the SEAS software will receive full credit toward awards in both programs by submitting Sail Plans and weather reports. Because SEAS messsages use a special compressed format, there is no charge to the ship for either AMVER or met messages.

If your ship has a PC on the bridge and INMARSAT C you may write for this software to :

Observing Networks Branch
N/OES42 SSMC4 Rm 6308
1305 East West Highway
Silver Spring, Md. 20910-3281
Tel: (301) 713-2790
Fax: (301) 713-4499

In order to register this software, NOAA needs the following information:

Ship Name
International Radio Call Sign
Brand of INMARSAT C
Version of Software⚓



Barogram chart from the PMO's office in Norfolk, Virginia, as Hurricane Bertha passed by.

National Data Buoy Center

Marine Observation Network In Prince William Sound

Eric A. Meindl
National Data Buoy Center
Data Systems Division

Since 1977, the U.S. Coast Guard has operated a Vessel Traffic Service (VTS) in Prince William Sound, Alaska, to assist tankers and other commercial vessels in safely navigating through the area. In part, VTS traffic management is based on the marine conditions in the area, which vary considerably due to the rugged topography.

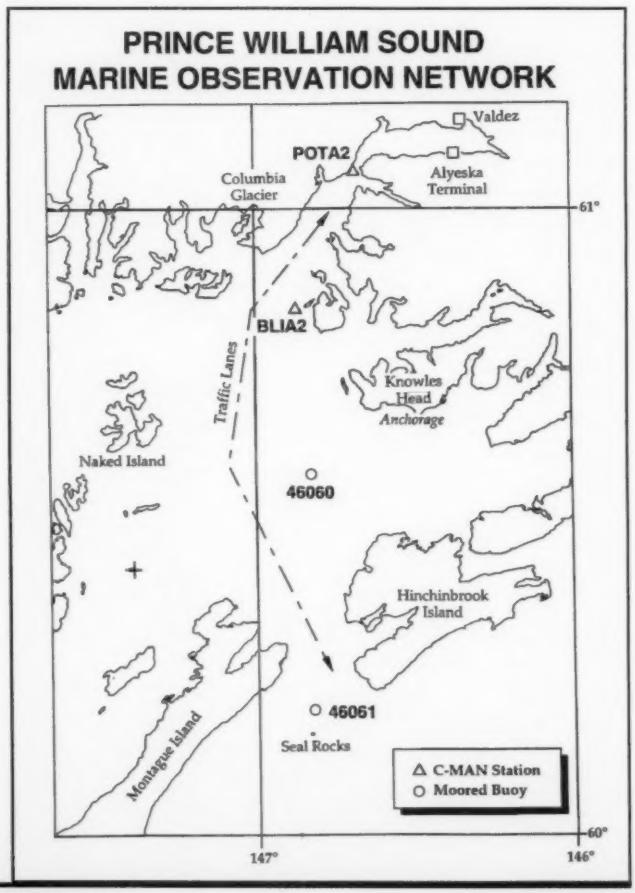
In 1995, the National Data Buoy Center (NDBC), a center within the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, installed four automated weather stations at critical locations in or near Prince William Sound. The mini-network consists of two moored buoys and two land-based Coastal-Marine Automated Network (C-MAN) stations (Figure 1). The moored buoys are located in the mid-Sound west of the tanker anchorage (identifier number 46060) and at Hinchinbrook entrance (46061); the C-MAN stations were erected at the south end of the Valdez Narrows (POTA2) and on Blight Reef Light (BLIA2).

All four stations measure average wind directions, average speed, and peak 5-s wind; barometric pressure; and air temperature. In addition, the buoys provide sea surface temperature, significant wave height, and wave period. The measurements are updated and transmitted via geostationary satellite every 30 minutes. Within 15 minutes, the data normally are available to the Coast Guard VTS and for broadcast over NOAA Weather Radio. NDBC coordinated efforts among several agencies to increase the frequency of reports from the stations.

Two different buoy hulls are being used. A 3-m discus foam buoy is stationed at 46060 in 450 m of water. This ionomer foam hull is being used because it is expected to fare better than a standard 3-m aluminum hull if struck by floating ice. Its measurements should accurately represent conditions in the open Sound. A more rugged, 6-m boat-shaped aluminum hull is anchored at 46061, near the entrance to the Sound, where meteorological conditions are more severe. Both the POTA2 and BLIA2 stations are towers that have been installed to obtain measurements as representative as possible of conditions over the adjacent channel waters.

All stations are equipped with dual anemometers and barometers. The redundancy serves two purposes: it increases reliability of data delivery and it allows NDBC data analysts to easily verify environmental data quality. These monitoring functions actually occur at NDBC's facilities located at John C. Stennis Space Center in southern Mississippi.

The network has been very reliable during the year following installation. The C-MAN stations have reported 79.5 percent of all expected meteorological measurements (that is, two observations per hour, with each observation containing winds, pressure, and temperature). The moored buoys have delivered 84.5 percent of all meteorological and 88.5 percent of all sea state observations. The addition of the NDBC network to other observations in the area has allowed officials and commercial interests to gain a significantly better knowledge of marine conditions near Prince William Sound, promoting safer operations.⚓



What's New With AMVER?

Richard T. Kenney
Maritime Relations Officer
United States Coast Guard

AMVER/VOS Compressed Message Software in the Testing Stage!

The long-awaited shipboard computer software which will bring up a combined AMVER/VOS report screen, thus eliminating the necessity for preparing two messages, is being tested for compatibility with various manufacturers' INMARSAT terminal equipment aboard a select group of ships at sea. The program will "compress" the report into binary format for transmission via both the signal and message channel of the satellite, thus also reducing costs for a typical AMVER sail plan message from $6.00 to .50¢ (US), at which point the U.S. government will underwrite the cost of the reports, even if sent via satellite. Currently, message traffic via coastal radio stations is subsidized, but INMARSAT users are charged at the regular tariff. Distribution of the software will be announced later this year.

First AMVER Rescue Made by Ship of the Peoples Republic of China!

On 15 April, the crew of the 770-foot Chinese containership GAO HE recovered retired U.S. Navy Captain William "Buzz" Radican from his 37-foot sailboat "SEAWEED," 850 miles west of San Francisco. Radican, 51, from Virginia Beach, Virginia, was sailing from Honolulu to San Diego when his vessel became disabled and started taking on water in heavy seas. The GAO HE was identified by AMVER as the closest vessel to divert and make the rescue. The ship was met by reporters and TV cameras on its arrival in Long Beach. The Chinese government just recently approved participation in AMVER by ships of the COSCO national fleet. Attaboy!

Survivor Capt. William "Buzz" Radican, USN (Ret.) and Capt. Ju-Gem Shen, Master of the M/V GAO HE, are joined by a local COSCO official and Radican's wife, Celine.

Greek Ship Selected for 1995 International Rescue at Sea Award!

The refrigerated cargo ship SANTORINI REX, of Akra Shipping Company Ltd. in Piraeus, Greece, accomplished the "AMVER Rescue of the Year" for 1995. A panel of U.S. Coast Guard search and rescue specialists, AMVER program officials, and representatives from LLP, Ltd. (formerly Lloyds of London Press) which sponsors the award, selected the ship for the 1995 IRAS Award. On 4 April 1995, SANTORINI REX was located by AMVER and vectored by a C-130 aircraft to the scene of the sunken Belize-registered M/V OLFEO 40 miles north of Columbia in heavy seas, where it recovered the OLFEO's nine crew members safely. The award will be presented, with the 1995 Greek AMVER Awards, by LLP Chairman Iain Lindsay-Smith at the annual Propeller Club dinner in Athens in September.

Association for Rescue at Sea Establishes Award for AMVER Ships!

The prestigious AFRAS organization has created an award for AMVER-participating ships which exhibit extraordinary seamanship, shiphandling, and heroism in the course of assisting another vessel in distress. The M/V NISSOS THERA, of Glafki (Hessal) Maritime Co., Athens, Greece, has been selected as the first recipient of this award, which will be presented at the U.S. Capitol Building in Washington, D.C., in September. On 8 March 1995, the Greek tanker copied a MAYDAY signal just north of the Canary Islands and diverted to assist. It arrived at the position of the sinking Spanish fishing vessel LOBOS. Over the next 90 minutes, the crew of NISSOS THERA would recover 15 persons from three life rafts.

Help on the Way?

At the International Shipping Exhibition in Posidonia in June, AMVER officials approached representatives of 15 national shipping registries, requesting that they encourage participation in AMVER by ships of their registries through circulars or articles in regular newsletters. Each new ship on the AMVER plot makes the system more effective for all!

AMVER representatives also approached P&I Clubs with a proposal for an insurance premium reduction for ships participating in AMVER. While such a significant precedent requires much study and evaluation of its economic implications, the agents of the major P&I Clubs at least agreed to entertain such a proposal for consideration!⚓

Coastal Forecast Office News

Atlantic Area

NWS Operates Olympic Support Facility

S.K. Rinard

The National Weather Service (NWS) assembled a team of experienced marine meteorologists to provide weather warning and forecast support to the 1996 Centennial Olympic Games Yachting Venue at Savannah, Georgia. Actual competition ran from July 22 to August 2. Included in the team was a meteorologist from Canada and one from Australia.

The purpose of the Olympic Marine Weather Support Center (OMWSC) was to ensure the safety and comfort of the teams and visitors at the Yachting Venue. The OMWSC used the meteorological and oceanographic models and hardware and software that are, or soon will be, operationally part of the modernized NWS.

Almost 600 athletes from roughly 78 countries competed in the Yachting Venue making it one of the largest in this Olympics.

Miami, FL NWFSO

Michael O'Brien

April through June of 1996 was almost uneventful. Miami's coastal and offshore waters were almost free of storms between the big system that developed off of Florida's east coast in early March and hurricane Bertha in the second week of July.

One notable event did occur and that was the development of tropical storm Arthur. Arthur formed from a trough off of Florida's east coast. Weak troughs are a common occurrence in winter and spring but some do form in the summer. Early on the 18th of June the closed low on the trough deepened to 1010mb at 27.6n 78.5w forming tropical depression one. The depression moved north and a little more than 24 hours later became tropical storm Arthur with a central pressure of 1006mb. At this time Arthur was already north of our forecast area. By nightfall Arthur moved inland in the Carolinas and began to disintegrate, having produced minimal gale force winds near Florida's and Georgia's coasts.

Washington, DC NWSFO

Brian G. Smith

Experienced mariners on the Chesapeake Bay know how quickly thunderstorms can fire up to produce strong, life-threatening winds and rough waves. The usual time for severe weather is from mid-afternoon until late evening, about 3 pm to 10 pm. Wind and lightening are the primary threats from thunderstorms.

The Bay can be a source of energy for thunderstorms. It produces moisture—water evaporating from the Bay. Also, the layout of the land and the contrast between air temperatures over land and over water favor formation of localized southerly wind maxima during the late afternoon and evening. These wind maxima are most noticeable between Patuxent River and Baltimore Harbor. Surface winds may increase to 20-25 knots at times. The wind maxima are a source of momentum to air flowing into thunderstorms to strengthen them. So if a thunderstorm approaches the Bay and it's already very intense, it's likely to get an energy boost from the Bay.

If you're on the Bay and thunderstorms threaten, get to a safe harbor as quickly as you can. Be aware of the hazard of lightning. The Bay is shallow, so steep wind-driven waves several feet high can develop in only a few minutes. WEAR A LIFE PRESERVER. If you're on shore and thunderstorms threaten, you're prudent if you don't set out until the threat has passed. Listen for severe weather warnings and special marine warnings on your NOAA weather radio.

Mariners, even pleasure boaters, are required to take courses in boating safety. Pay attention to the weather portion of the course. Some time in your tenure as a mariner, the weather will pose a threat to your life, and not just from thunderstorms. If you know what to do, you can save your life and the lives of your shipmates.

I'm taking this opportunity to tell you about the new home page of the NWS at Sterling. You can find it at the following address: http://www.nws.noaa.gov/er/lwx/

Also, I'm making a serious pitch for mariners on the Bay to send weather reports to the NWS. We marine forecasters have a longstanding need for wind and wave observations within the Bay. Operators of larger commercial vessels who send in ship reports are encouraged to transmit weather observations as their duties allow at synoptic times (0000 UTC, 0300 UTC, etc.), just as though they were on the ocean. As for pleasure boaters, the NWS at Sterling is working with cell phone companies to see whether a free call arrangement can be made so that people can, if they wish, send a report directly to the NWS. All marine weather reports will be well used and very much appreciated.

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Mt. Holly, New Jersey (Philadelphia) NWSFO

Jim Eberwine, Marine Focal Point

The Basic Marine area for the Forecast Office at Mt. Holly, New Jersey, extends from Sandy Hook to Cape May, New Jersey (124 miles), the Delaware Bay and Atlantic coastal Delaware from Cape Henlopen to Fenwick Island, Delaware (24 miles), to 20 nm offshore. With the seaward coverage of the PHI doppler radar, the forecast area will extend out to 100 nm April 1997. The overwater Doppler coverage extends from an azran of 059 degrees to 199 degrees. As you can see, although the Doppler radar umbrella has one of the largest populations under it, its overwater coverage is also quite large.

The northern part of our forecast area is under the 1st Coast Guard District Headquarters in Boston Mass. The southern end (Barnegat Inlet to Indian River Inlet, Delaware) is covered by the 5th Coast Guard District in Portsmouth, Virginia.

Forecasts are prepared four times daily at approximately 3 am and 9:30 am, and 3 pm and 9:30 pm. If the weather is changing faster than expected, or if we receive reports from mariners that the forecast is different than what is being observed, the forecast is updated.

Continuous wind and wave data is received from Ambrose LS (entrance to New York Harbor 40.46.N/ 73.83.W) as part of the Coastal-Marine Automated Network (C-MAN), and from two moored buoys, Delaware Light-44009 (38.5N/74.7W) and Long Island (40.3N/73.2W). The National Data Buoy Center (NDBC) is responsible for the deployment and maintenance of the buoys. The information is received each hour and incorporated into a local work file that the NWSFO Mt. Holly uses for forecasts and broadcasts each hour. Forecasters Jim Eberwine and Robert Wanton were guests of the NDBC and U.S. Coast Guard buoy tender Hornbeam when a refurbished buoy 44009 was put into service in December 1995.

We receive daily marine reports from three primary sources. "Sand Dollar," broadcasting from Harvey Cedars, Long Beach Island, New Jersey, calls us with existing conditions off the New Jersey coast. The calls are regularly received in the morning and updated if there is a significant change in the weather. The "Whitestar" and other vessels relay many reports to us through Sand Dollar. The reports include both swells and wind waves, and a variety of other elements.

The Cape May Lewes Ferry will phone reports to us in the morning and afternoon which gives us an excellent idea of what the weather is across the mouth of the Delaware Bay (approximately 10 miles).

The most frequent and numerous reports are sent to us as part of the Marine Reporting Network (MAREP). The University of Delaware Sea Grant Marine Advisory Service collects the observations from mariners in the Mid-Atlantic coastal and offshore waters. These reports are sent several times each day from the communications center at Lewes, Delaware. They receive the reports over VHF Channel 16 and single sideband 2096.5. The reports are then broadcast from the Mt. Holly office over the NOAA Weather Radio frequencies 162.55-162.40 and 162.475MHZ on the VHF-FM dial. All of these reports improve the overall marine forecast program.

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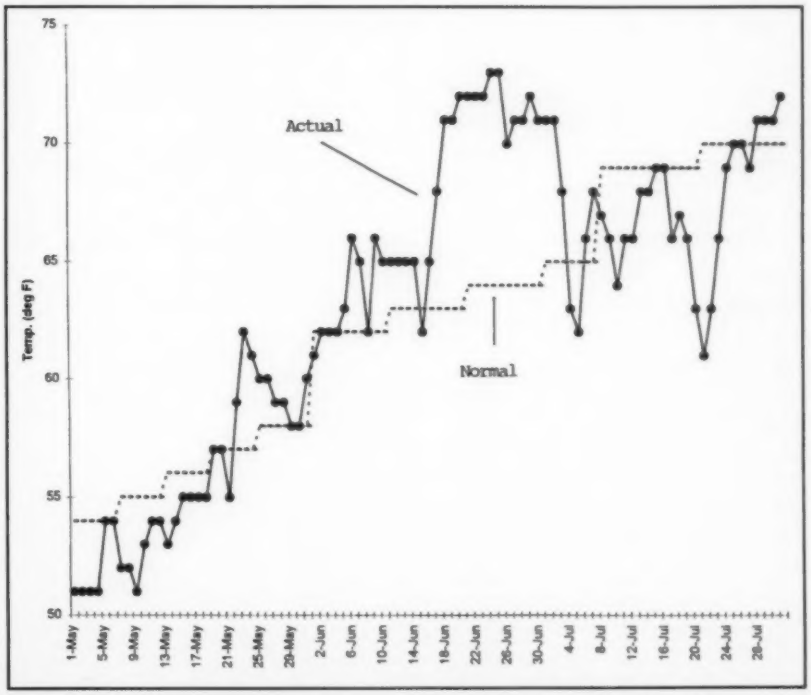

Plot of the ocean temperature versus normal for the Atlantic City, New Jersey, area from May 1 through July 31, 1996.

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The NWSFO Mt. Holly provides forecasts for one of the largest recreational fishing areas on the east coast. According to 1993 statistics from American Sportfishing Association, there are over 1 million (1,101,000) anglers in New Jersey and Delaware. New Jersey registers 889,000 of them. The number of fish caught off New Jersey waters is 28,145,000 and 3,665,000 for the state of Delaware.

An old saying "wind in the west suits everyone the best," is not particularly true for the fishermen. In fact, a southwest to west wind will bring unwelcome cooler waters to the nearshore areas. Fishermen have known for a long time that these winds bring cooler water temperatures, but are not quite sure why.

The process by which the warmer surface waters are carried out to sea and replaced by cooler underlying water is known as upwelling. The NWSFO Mt. Holly has developed an upwelling index which can alert forecasters, and the marine community in general, of a strong upwelling event. These events are nothing unusual, but the magnitude can vary significantly. The Bermuda high pressure that resides along the mid-Atlantic coast brings south to southwest winds to the region. The more persistent the wind, and the strength, determines the overall outcome. The temperature on a normal day with south to southwest winds will drop around 5 to 8 degrees. However, an extreme event occurred in the summer of 1988 when, in a two week period, the water temperature dropped 26 degrees from 79 to 53 degrees during the height of the summer season. There were some isolated reports of 49 degrees.

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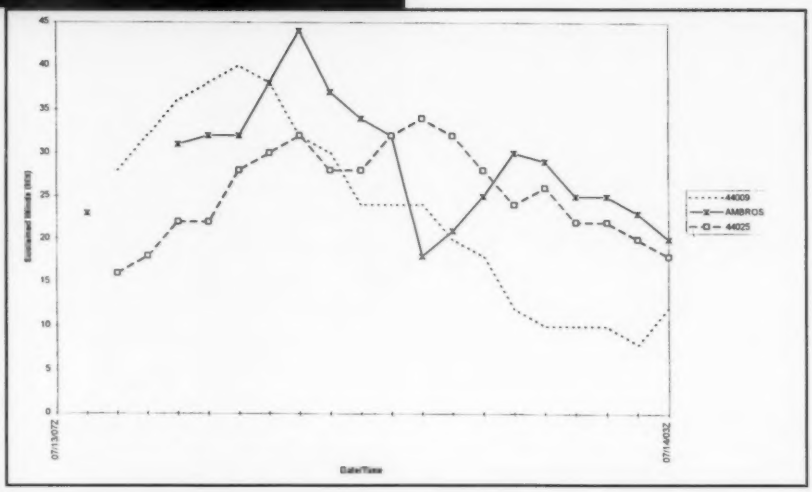

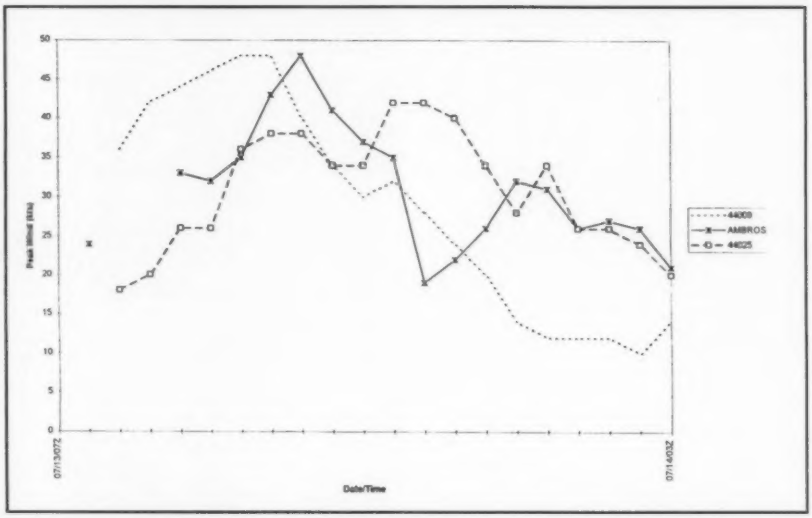

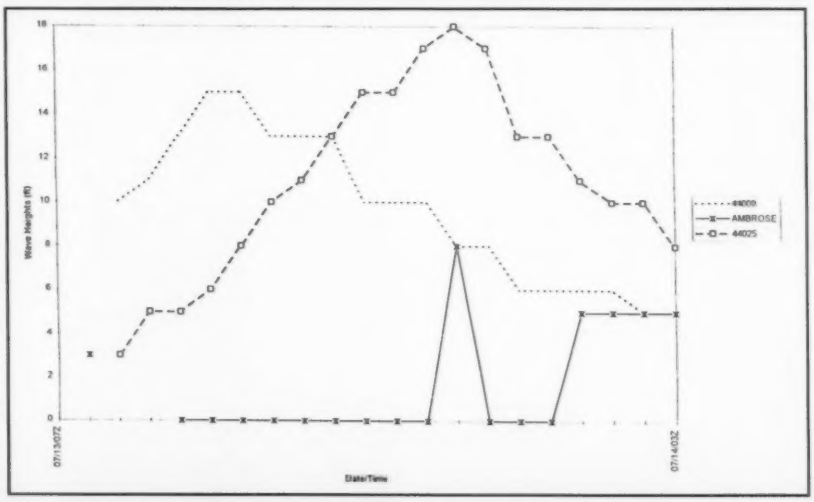

The three charts above reflect the sustained winds, peak wind, and wave heights for buoys 44009 and 44025, and Ambrose LS. These are the primary observations within the Basic Marine Area of Mt. Holly, New Jersey.

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Some additional effects of upwelling include fog and a very cold day at the beach for bathers. Extensive fog develops as the warmer air temperature overrides the newly surfaced cooler waters and limits the visibility to zero for much of the day. The upwelling events have extended well out to sea, reaching the Delaware Light buoy 4409, and the Long Island buoy 44025. The recovery to warmer waters occurs very quickly as the south to southwest winds diminish and an onshore flow returns again. The water temperatures can rebound in less than a day. When cool waters are upwelled, the more popular game fish are driven farther offshore. This in turn causes fishermen to extend their fishing day and use much more fuel than normal.

The forecasters at Mt. Holly have nearly 200 years' combined experience in marine weather. It is a very dedicated staff that tries to ensure that everyone leaving the dock in the morning returns at night!

Upton, New York NWSFO

Ingrid Amberger, Marine Program Leader

The National Weather Service Forecast Office in Upton (Brookhaven) NY (OKX) is honored to be part of the quarterly Mariners Weather Log. We would like to share more about our operations and office with you.

The following are NWS's definitions for the advisories, warnings, and watches for forecast waters. Our marine forecast/warning area covers the coastal waters from Watch Hill, Rhode Island to Montauk Point, New York, to Sandy Hook, New Jersey, extending 20 nautical miles offshore and including Long Island Sound and the New York Harbor.

Advisories:

A **Heavy Surf Advisory** is issued for heavy or high waves which may pose a threat to life and property. Example: Large waves breaking on the shore because of swell from a distant storm.

A **Small Craft Advisory** is issued when sustained winds of 25 to 34 knots and/or seas 6 feet or higher are expected or occurring. Small Craft Advisories are issued up to 12 hours before the conditions are expected and are not associated with tropical systems. If sustained winds are under 25 knots but seas are 6 feet or higher, a Small Craft Advisory for rough seas will be issued. (Sea criteria may vary from region to region.-Ed.)

Warnings:

A **Coastal Flood Warning** is issued when tidal or storm induced flooding is occurring, imminent, or highly likely along coastal areas within approximately 12 hours.

A **Gale Warning** is issued when sustained winds of 34 to 47 knots are expected or occurring. Gale Warnings are issued up to 24 hours before the conditions are expected and are not associated with tropical systems.

A **Hurricane Warning** is issued when sustained winds are expected to be 64 knots or higher, associated with a hurricane. Hurricane Warnings are issued up to 24 hours before the conditions are expected.

A **Severe Thunderstorm Warning** is issued when winds at least 50 knots and/or hail at least 3/4 inch in diameter are imminent or occurring. The warning will include the location of the storm, its movement (speed and direction), and the primary threat from the storm.

A **Special Marine Warning** is issued when winds are expected to exceed 34 knots, especially in gusts, for a period of 2 hours or less. Special Marine Warnings are typically issued when thunderstorms are expected to produce strong gusty winds.

A **Storm Warning** is issued when sustained winds of 48 knots or higher are expected or occurring. Storm Warnings are issued up to 24 hours before the conditions are expected and are not associated with tropical systems.

A **Tornado Warning** is issued when a tornado is imminent or occurring. The warning will include the location of the storm or tornado and its movement (speed and direction). Note: A waterspout is a tornado over water.

A **Tropical Storm Warning** is issued when sustained winds are expected to be 34 to 63 knots, associated with a tropical storm. Tropical Storm Warnings are issued up to 24 hours before the conditions are expected.

Watches:

A **Coastal Flood Watch** is issued when conditions are favorable for tidal or storm induced flooding along coastal areas within approximately 12 to 36 hours, but the occurrence is still uncertain.

A **Hurricane Watch** is issued when conditions are favorable for a hurricane or hurricane conditions to develop over or close to a specific coastal area within 36 hours, but its occurrence is still uncertain.

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A **Severe Thunderstorm Watch** is issued when conditions are favorable for the development of severe thunderstorms in and close to the defined watch area.

A **Tornado Watch** is issued when conditions are favorable for the development of severe thunderstorms and possible tornadoes in and close to the defined watch area.

A **Tropical Storm Watch** is issued when conditions are favorable for a tropical storm or tropical storm conditions to develop over or close to a specific coastal area within 36 hours, but its occurrence is still uncertain.

Please visit our homepage on the Internet: **http://www.nws.bnl.gov./~nws**

Our homepage has numerous specialized pages.

Weather Pages:

- Products
- Satellite
- Radar
- Climate
- Watch/Warning/Advisories
- Marine (forecast and marine/tropical data)

Information Pages:

- Staff
- Education
- Meetings/Events
- Training
- Skywarn
- Other NWS Homepages

Taunton, Massachusetts NWSFO

Tom Fair

The spring season is usually characterized by a retreat of the westerlies northward and a decrease of strong extratropical cyclone frequency. Severe local storms in the form of thunderstorms become the main feature of concern. Such was the case this year in southern New England. The recent installation of the doppler weather radar in Taunton, Massachusetts, has provided us at the National Weather Service with a very detailed presentation of precipitation, wind, and interior features of thunderstorms. So on May 21, 1996, when strong convection was expected to develop, we were on alert and, in fact, by afternoon two bow echo complexes with very strong straight line winds appeared on the radar. Being in a good upstream location from the coast, we feel that providing good marine forecasts and warnings are possible. As a bow echo or thunderstorm apparent as a convex arc pointing in the direction of travel reached the Rhode Island Bays, a Special Marine Warning was issued for winds in excess of 50 kts. Even though a Small Craft Advisory had been in effect for 20 to 30 kt winds all day, we transmit the Special Warnings for specific threats. Sadly, even though we feel we had issued timely information, a 14-year-old boy was presumed drowned on the Acushnet River when his homemade raft overturned. It is assumed that wind and waves promoted the mishap. The storm then continued on across Massachusetts Bay to Provincetown at the extreme north end of Cape Cod where a few boats were overturned and windows were smashed.

Gulf of Mexico Area

San Antonio, TX NWSFO

Constantine Pashos, Marine Program Leader

The National Weather Service Forecast Office located in New Braunfels, Texas, was formerly the San Antonio office. The office has marine forecast and long-fuse warning responsibility for the Texas coastal waters from Beaumont to Brownsville and out 50 nm. The forecasts are divided up into upper and lower coast. The demarcation is at Port O'Connor. In addition, a local forecast is done for the Galveston Harbor entrance. Long-fuse warnings for small craft advisories, gale warnings, and storm warnings rests with the NWSFO. Short-fuse warning responsibility for special marine warnings and marine weather statements rests with the NWSOs along the coast in Houston, Corpus Christi, and Brownsville. Hurricane and tropical storm warning responsibility rests with the Tropical Prediction Center (formerly the National Hurricane Center) in Miami, Florida. Off the Texas coast there are three buoys. They are 42019, 42020, and 42035. Buoys 42019 (27.9N/95.0W) and 42035 (29.2N/94.4W) are in the upper waters and are used for input into the forecast for that zone, with buoy 42035 used additionally for the Galveston Harbor entrance. Buoy 42020 (27.0N/96.5W) is in the lower waters and is used for input into the forecast for that zone. In addition, there are weather observations performed along the coast. For the upper coastal waters there are Galveston and Palacios, while for the lower coastal waters there are Rockport, Port Aransas, Naval Air Station Corpus Christi, and South Padre Island. At

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times, there are differences in the wind speed over the waters and that over land where these stations are located and as a result, these are used with caution as forecast input. Reports from the Coast Guard, Harbors, and lifeguards are received at the coastal NWSOs. Currently, the NWS is undergoing a modernization and reorganization. During this period, responsibilities and forecast areas will change. Upon the commissioning of all the coastal NEXRADs (doppler radars), expected sometime in 1997, the forecast areas will change from 50 nm to 100 nm offshore. In addition, areas will be delineated to better reflect radar coverage into new zones. The areas will be divided at High Island, Port O'Connor, and Baffin Bay. Upon the completion of Stage 2, which includes fully staffed coastal offices and commissioning of AWIPS (the NWS new computer and dissemination system), forecast and long-fuse warning responsibilities will be transferred from the NWSFO to the NWSOs (renamed WFOs). WFO Lake Charles, Louisiana, will have responsibility east of High Island, WFO Houston from High Island to Port O'Connor, WFO Corpus Christi from Port O'Connor to Baffin Bay, and WFO Brownsville from Baffin Bay to Brownsville.

Great Lakes Area

Cleveland, Ohio NWSFO

Daron Boyce

After a very tough beginning to the Great Lakes shipping season, operations quieted down to a smooth routine early this summer.

Ice cover remained on the northern waters of the lakes until the end of May, although navigationally significant ice melted earlier in the month. Both Coast Guard and commercial ships sustained considerable damage during the Spring breakup season. A massive effort by the combined U.S. and Canadian Coast Guard, as well as commercial icebreakers, was needed to keep vessels moving during the prolonged end of season.

Two projects are under way on the Lakes to provide better services to users over the next year. A meeting was held in Cleveland on June 27th with the Lake Carriers Association communications committee to determine specific user needs for ice information. Plans are already being formulated for next winter and a more detailed written survey will be prepared this summer for users to express their needs.

Plans are being considered to share Great Lakes Ice services between agencies in the United States and Canada to avoid duplication of effort and to cut overall government costs. The launch of a new radar satellite which can look down on each portion of the Great Lakes about every three days will be a key factor in providing better information to shippers. This satellite can see through cloud cover and most storms to display pictures of the ice pack below.

A very detailed numerical model which will provide advanced forecasts of wave heights, water levels, and even the thermal structure and currents of the lakes is under development. The ongoing research, which has been underway for several years by students and staff at Ohio State University and NOAA's Great lakes Environmental Research Labs, will result in an operational computer model which will be run twice a day at the Weather Service Forecast Office in Cleveland late this year.

Forecasters in several NWS offices making marine forecasts will use the model output to fine-tune their products for both commercial and recreational users. After a verification study is completed, the actual model output may become available to the general public in various forms yet to be determined.

Cleveland, Ohio NWSFO

Kevin M. Woodworth, Marine Forecaster

The forecast/warning area for the Forecast office at Cleveland consists of two parts: (1) the Open Waters forecast, which covers all of Lake Erie, beyond five nautical miles from shore; and (2) the Nearshore forecast, which covers the area within five nautical miles of Lake Erie from Maumee Bay at the western border of Ohio to Ripley, New York.

Observational data is compiled from numerous areas across the Great Lakes. Buoy data, C-MAN observations, commercial shipping reports, coastal observational offices, Coast Guard reports, and MAREPs are all used in the preparation of marine forecasts. Here at the Cleveland forecast office, we input the data into our computer system, which is then loaded into a computer model program, which in turn produces a wave forecast for each of the Great Lakes. This computer model is called the Great Lakes Wave Model, and was developed by the Great Lakes Environmental Research Laboratory (GLERL), located in Ann Arbor, Michigan.

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The marine forecasts are prepared four times a day and are available through several different sources. Most of our recreational boaters receive this information over NOAA weather radio, which broadcasts from five different locations across northern Ohio and northwest Pennsylvania:

1) WXL-51 (Toledo, OH), which broadcasts on a frequency of 162.55 MHZ and covers the immediate Toledo area in northwest Ohio

2) KHB-97 (Castalia, OH), which broadcasts on a frequency of 162.40 MHZ and covers from approximately Toledo east along the lakeshore to Lorain

3) KHB-59 (Chesterland, OH), which broadcasts on a frequency of 162.55 MHZ and covers from Lorain to the Ohio-Pennsylvania border along Lake Erie

4) KDO-94 (Akron, OH), which broadcasts on a frequency of 162.40 MHZ and covers the inland areas of northeast Ohio

5) KEC-58 (Erie, PA), which broadcasts on a frequency of 162.40 MHZ and covers the northwest Pennsylvania shoreline

We have a new home page on the Internet. Our home page address is **http://csuohio.edu/nws**. This Internet site contains information about the office here in Cleveland, weather forecasts, climate and observational data, and links to many other weather "sites" on the Internet.

The spring and early summer season, ending June 30th, saw a cool and rather wet time across the Great Lakes. A persistent upper level trough over the Great Lakes and the northeast U.S. allowed numerous cold fronts to drop across the area through the end of June, keeping overall mean temperatures below normal throughout the period. This resulted in a slow ice melt for all the lakes, including Lake Superior, which continued to hold ice through the end of May. Even at the end of June, when water temperatures across Lake Erie had moderated to around 70 degrees, Lake Superior water temperatures remained in the mid to upper 30s.

Pacific Area

Eureka, California NWSO

John Lovegrove

MAREPs on the West Coast—Filling in the Gaps

National Weather Service marine forecasters have a major handicap as compared to their terrestrial counterparts—lack of data. In order to write accurate forecasts, a meteorologist needs to know the current conditions in both the forecast area and the region surrounding it. From this initial state, the forecaster can project ahead in time to write a forecast for some time in the future. It would be hard to write a high temperature forecast for San Francisco if you didn't know what the high was yesterday. The same thing applies to forecasting wind and waves.

For land forecasters, the NWS gathers data from airport observations, automated weather stations, volunteer observers, radar, satellite, and balloons. Over the ocean; satellite, radar near shore, a handful of buoys, and a few volunteer ship reports are the only data sources. Of these, only buoys and ships report wind and waves. A marine forecaster is virtually blind.

This is where the commercial fisherman, recreational boater, tug operator, and other mariners can help. By participating in the Mariner Report or MAREP program, mariner's can fill in the gaps offshore. MAREPs are weather observations radioed to an NWS office or to a cooperating shore station and then forwarded to the marine forecaster. MAREPs began on the East Coast and became popular in Alaska. Until recently, they haven't been used much on the Washington, Oregon, or California coasts. The National Weather Service office in Astoria, Oregon, has had a program going for the past few years and now all West Coast NWS offices either have MAREP programs or are planning one.

The West Coast has volunteer radio operators as well. In Grays Harbor, Washington, Josie Dyas has been relaying weather information to the Seattle NWS office for 12 years. She has received numerous awards for her work and has undoubtedly saved many lives.

What information is in a MAREP? How do you get it to the NWS? A complete MAREP contains the following information:

1) Who – Call sign or vessel name
2) Where – Approximate location
3) Wind speed and direction
4) Seas
5) Visibility
6) Present weather

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You can also include some optional information:

7) Barometric pressure
8) Air temperature
9) Sea temperature
10) Remarks (feel free)

How often and when to report depends on what NWS office or shore station you are operating near. Table 1 lists the West Coast MAREP programs and their hours of operation.

You don't have to spend a lot of money or time to participate in the MAREP program. Wind speeds can be estimated using the Beaufort Scale and sea conditions are always estimates. Many ships carry barometers and thermometers.

An investment of a few minutes of your time to make a report could save you hours of battling rough seas. Remember: MAREP means self-help. For more information on the Mariner's Report program, contact your nearest National Weather Service office.

Los Angeles/Oxnard California NWSFO

Robert Burke, Forecaster

The National Weather Service Forecast Office Los Angeles/Oxnard (NWSFO LOX) has responsibility for one of the largest marine communities in the United States. Our area of forecast responsibility is divided into two zones. The first one being the inner waters from Point Conception to San Clemente Island down to the Mexican border. The second one is the outer waters from Point Sal to Point Conception to San Clemente Island and out to 60 nautical miles offshore. These two zones have distinctly different weather patterns.

The inner waters generally have a typical land/sea breeze circulation. With an irregular coastline along southern California, the local sea breeze winds will range in direction from south-southwest to west-northwest. Afternoon wind speeds tend to be in the 10-15 kt range and swells are generally less than 4 feet. One exception is the Santa Barbara Channel where afternoon winds are stronger and swells tend to be higher than the rest of the inner waters. Wind speeds of 25 kt or more occur with a greater frequency than the rest of the zone with small craft advisory (SCA) conditions occurring a higher percentage of the time.

The outer waters have a general northwest wind flow. This flow is typically stronger than the inner waters with SCA conditions occurring a higher percentage of time. Due to the topography around Point Conception, the waters from Point Sal to Santa Rosa Island have wind speeds that are usually stronger than anywhere else in our area of forecast responsibility with SCA conditions required a very high percentage of the time and gale warnings being posted on occasion. Swells in the outer waters tend to range from 4-8 feet with heights of 10 feet or more occurring on occasion requiring an SCA. These swells are usually from distant storms in the north Pacific.

Meteorologists at NWSFO LOX have been busy lately supplying the marine community with marine information. John Henderson (Marine Focal Point), Robert Burke (Forecaster), and Bob Webster (Port Meteorological Officer, Long Beach, California) recently participated in the 13th Annual American Boating Jubilee along the shore of Long Beach, California, in July. Besides handing out brochures and answering marine related questions, a computer was set up with Internet access allowing us to show people what types of information and products are available to them through our homepage on the Internet. Our Internet address is as follows: www.wrc.noaa.gov/oxnard/oxr3.html

Robert Burke also gave a talk to the Pacific Singlehanded Sailing Association at Marina Del Ray in Los Angeles on July 8th. Besides showing them what types of products are available on the Internet and talking about marine weather in general, an overview of the new Santa Barbara Marine Weather Radio, known as Weather-3,

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Station	VHF Channel	SSB Freq or Chan	Phone	Hours
Grays Harbor, WA	68, 69	2096, 4125, 6224, 8294	N/A	7 am to 10 pm *VHF 16 monitored 24 hrs*
Astoria, OR	16, 69, 68			*VHF 16 monitored 24 hrs*
Eureka, CA	16, 70, 71	450, 452, 453 850, 851, 852	(707) 443-6484	7:30 am 1:30 pm *VHF 16 monitored 24 hrs*
Monterey, CA	COMING SOON! STAY TUNED!			
Oxnard, CA	IN THE PLANNING STAGES			
San Diego, CA via Scripps Institute	9	602		8:00 am to 4:30 pm

Table 1. West Coast MAREP Programs.

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was presented. This new station became operational on July 1st and is provided in cooperation with the Santa Barbara County Fisheries Enhancement Group. It is designed mainly to serve the marine community of Santa Barbara and Ventura counties, as well as the adjacent coastal waters, and will contain only marine information.

Seattle, Washington NWSFO

Bill Burton, Marine Program Leader

NWSFO Seattle does the forecasts for the Washington coastal waters out to 60 nm (Cape Flattery to the mouth of the Columbia River), the Strait of Juan de Fuca and Admiralty Inlet, Puget Sound, Hood Canal, and for the northern inland Washington waters, Camano Island to Point Roberts.

We also do an offshore forecast for 60 to 250 nm offshore and two bar forecasts for the Grays Harbor and Columbia River Bar.

The main way to receive our marine forecast products is via NOAA weather radio. There is also a call-in to the Seattle Times information line which has all of our marine forecasts. Radio stations mostly use ours. Marine fax transmitted from San Francisco may also have some of our products and NCEP's products on it.

Kodiak, Alaska WSFO

Steve Kuhl, Officer in Charge

Kodiak is the third largest commercial fishing port in the United States in total value. According to 1993 statistics, the port of Kodiak's fishing value was set at $82,000,000, with 2,636 commercial fishing vessels registered with the harbormaster. In addition to this huge fishing fleet, the largest United States Coast Guard (USCG) Base in the world is located only 5 miles south of the city of Kodiak.

WSO Kodiak is dedicated to providing timely and accurate marine weather forecasts and warnings to the vast user community. The WSO broadcasts numerous daily NWS marine products via the NOJ Marine Radiofacsimile at 0400, 1000, 1800, and 2200 UTC to the fishing fleets in the Gulf of Alaska and the Bering Sea. These products include: Alaska surface analyses; Alaska coastal marine forecast tables; Alaska 3, 4, and 5 surface forecasts; Alaska 36-hour surface forecasts; 5 day sea ice forecasts; sea surface temperature analysis; and significant wave forecasts.

At 8 am and 6 pm local time, NWS-prepared marine forecasts for the Alaskan waters stretching from Ketchikan, west to Attu Island and north to Kotzebue Sound, are broadcast via High Frequency (HF) radio by Mrs. Peggy Dyson (under NWS contract). Peggy has been performing these broadcasts for over 25 years. Additionally, Very High Frequency (VHF) radio is used by the WSO Kodiak staff to broadcast marine forecasts to mariners for the waters surrounding Kodiak Island at 6 am and 5 pm local time. Of course, NOAA Weather Radio provides current marine forecasts to the customer 24-hours a day, 7 days a week.

The WSO Kodiak marine program also provides personalized ship visitation services to the marine community. Upon request, Steve Kuhl, WSO Kodiak Meteorologist-In-Charge and Port Meteorological Officer, will visit a vessel to perform a barometer calibration and discuss the Kodiak marine program, as well as any issues of concern, with the customer. Additionally, Steve and Jim Peronto, NWS Meteorologist Intern, visited the USCG Cutters Firebush and Storis to provide a "hands on" training seminar in the interpretation of the NWS charts, which are transmitted via the NOJ marine radiofacsimile program during December 1995 and January 1996, respectively. Steve has also recently recruited the vessels "Woldstad" and "Trooper," of the State of Alaska, Department of Public Safety, Fish and Wildlife Protection, Marine Services, into the NWS Volunteer Observing Ship (VOS) program.

Monterey, California NWSFO

Wilfred Pi

New Models Used By The National Weather Service

The National Weather Service is experimenting with new forecast models that will improve marine forecasting in the future. One such model, called the Meso-Eta, is similar to the currently existing model, the Eta model, except it has a horizontal resolution of 29 km and 50 vertical layers (compared to 80 km and 38 vertical layers on the Eta model). The extra vertical layers allow for better representation of the mountainous terrain over land and will allow for better computer-generated weather prognostics. The improved horizontal resolution on the Meso-Eta model allows small-scale weather features that the currently used models fail to depict to be seen and forecast. One such example is the Catalina eddy that forms several times a year off the southern California coast. Supported by buoy data, the Meso-Eta's surface

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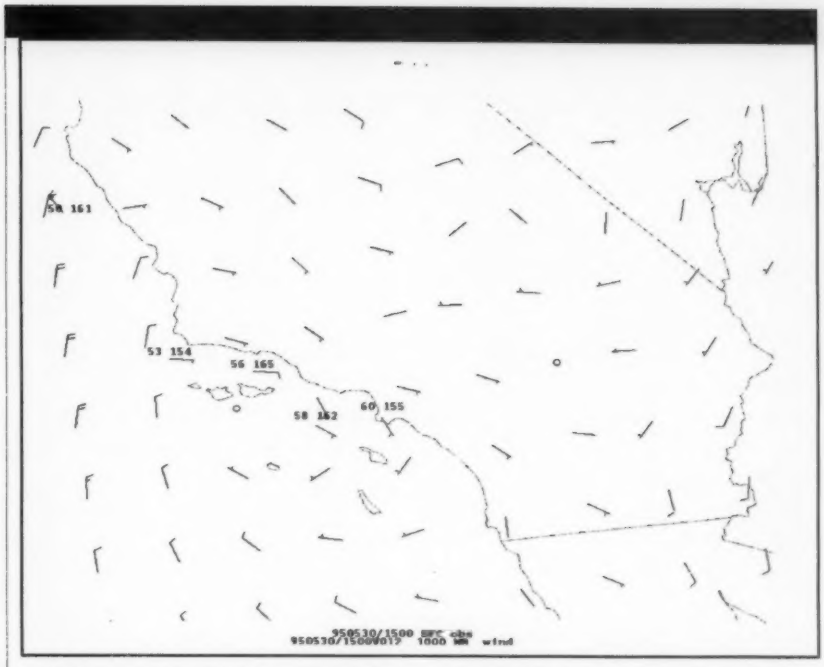
wind forecast has shown it can predict the formation of a Catalina eddy within 24 hours. This is the first time a model has been able to see this feature, as the size of the Catalina eddy averages only 40 km in diameter. This model, however, does not always forecast a Catalina eddy when one actually forms nor does it perform well in forecasting it 24 hours or more ahead of time.

The surface winds of the Meso-Eta model assist in seeing some localized weather features. In California, the Meso-Eta is able to distinguish the frequently stronger westerly winds funneling through the Santa Barbara Channel from the lighter winds further out to sea. The Meso-Eta can also be helpful in forecasting winds where there is no buoy data, which is beyond 10 nm off the coast. This will assist marine forecasters in the issuance of small craft advisories or gale warnings, taking the entire area of responsibility into account. Often the Meso-Eta model will forecast winds less than 20 knots near shore and winds that exceed small craft advisory beyond 10 nm out which are in agreement with ship and buoy reports. But most of the time, these forecasted winds cannot be verified due to lack of ship data.

Another challenge to marine forecasting in California which we hope to solve by using the Meso-Eta occurs when a frontal system approaches the Pacific Northwest with the tail end of the front skirting the northern coastal waters of California. In this situation, southerly winds ahead of the front only affect a portion of the northern California waters while the winds over the remainder of the California coastal waters stay northwest. Current models generally have little problem forecasting winds when strong synoptic-scale storms roar through California, but they do not do well in forecasting how

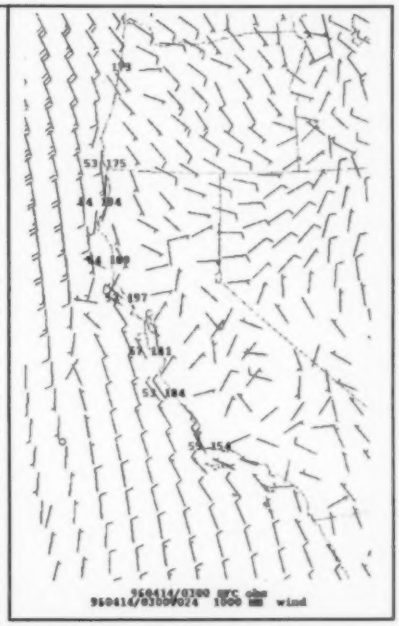


A 12-hour surface wind forecast by the meso-eta model shows a Cataline eddy near the Channel Islands. Buoy reports, the wind barbs associated with air temperature and sea level pressure, verify the presence of the eddy.

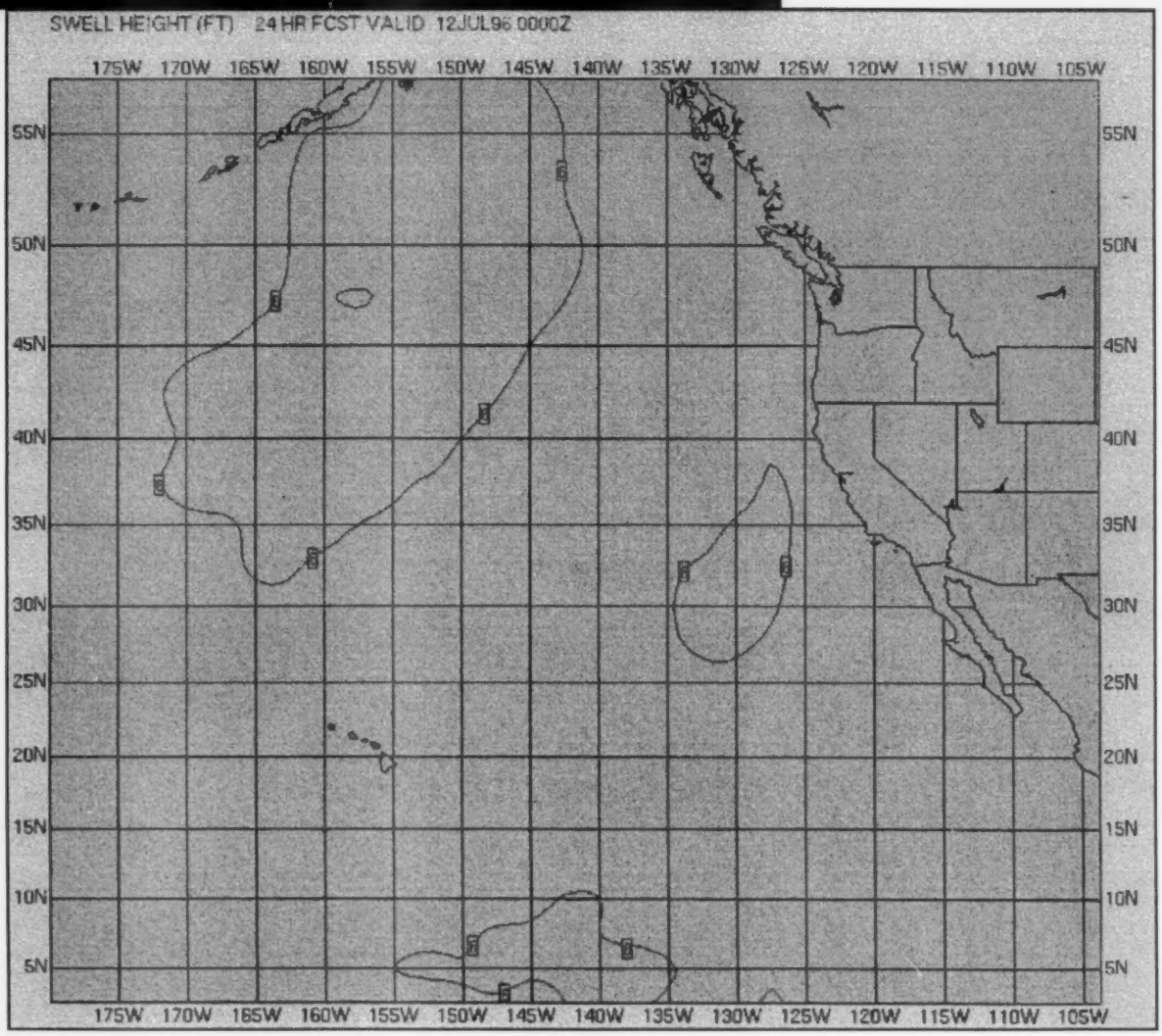
far down the coast the southerly winds will go when only the tail end of a front is present. The Meso-Eta, with its higher resolution, will allow forecasters to better see the boundary line where northwest winds become light, then shift to a southerly component. During the month of March 1996, a series of fronts moved through Washington and Oregon trailing into northern California. The Meso-Eta was excellent in forecasting this boundary during that month.

Computer models are available for forecasting sea conditions as well. The National Meteorological Center's Marine Forecast Branch issues a 24-hour wind/wave forecast for the eastern Pacific Ocean twice a day. The Ocean Wave Model is produced by the National Meteorological Center's Global Aviation Model for the National Weather Service. Wave data is

Continued on Page 64



The Meso-Eta model's 24-hour surface wind forecast shows the boundary between southerly and northwesterly winds as a cold front approaches the Pacific Northwest. Buoy reports agree well with the model output.



FNMOC oceanographic model's 24-hour swell forecast of the eastern Pacific.

Coastal Forecast Office News

Continued from Page 63

collected by the GOES satellite and the Aviation Model provides combined wave height, wave period, and wave direction forecasts for 24, 48, and 72 hours out. The National Weather Service in Monterey, California, which is co-located with the Navy's Fleet Numerical Meteorology and Oceanography Center (FNMOC), now has access to the FNMOC's own wave model. The FNMOC model forecasts sea and swell heights separately as well as period and direction every 12 hours out to 84 hours. A computer mouse can be pointed to a spot on the map and the information will be interpolated for that spot. For forecasting very large swells, the best method has always been using current surface map analysis to find areas of large waves generated out in the Pacific Ocean (a fetch) that propagate towards the California coast. Knowing the length of the fetch, wind direction, speed and duration, and distance from the fetch to the target, a good approximation of swells can be forecast for the California coastal and offshore waters two to three days ahead. This method was developed over twenty years ago and is preferred over computer models when forecasting for large swells.

For anyone who is interested in seeing a sample of the graphic output of the Meso-Eta model, the surface wind forecast is accessible via the Internet on the National Weather Service, San Francisco Bay Area home page: www.nws.mbay.net/home.html.⚓

Whale Oil & Wicks

Turkey Point Lighthouse

Elinor De Wire
Gales Ferry, CT

At the head of the Chesapeake Bay is a 10-mile-long, forested peninsula enclosed by sharp, buff-colored cliffs rising almost 100 feet above high water. Captain John Smith, on his voyage up the bay from the Jamestown Colony in 1607, noted that the cliffs could be seen from a great distance and served as an excellent daytime navigating aid.

Two centuries later the U.S. Lighthouse Service, operated by the Treasury Department, ordered a light tower built on the point—by then known as Turkey Point—to aid ships traveling at night. It was one of the earliest lighthouses built on the Chesapeake Bay and a structure that reflected the frugal and practical nature of the United States' fledgling lighthouse establishment.

The quaint, 35-foot Turkey Point Lighthouse, completed in 1833, signaled to traffic heading up the scenic Elk and Northeast rivers—minor tributaries of the mighty Chesapeake but important arteries leading to the great Susquehanna River and, in later years, the busy Chesapeake and Delaware Canal. The conical brick tower was white-washed, with a bright red iron lantern cap, to help it show up well against the forest background.

The builder of the historic lighthouse was John Donahoo, a town commissioner from nearby Havre de Grace who built several other Chesapeake Bay lighthouses, including Concord Point Light, a near duplicate of the Turkey Point tower. The cost for the brick lighthouse and keeper's dwelling at Turkey Point was $4,355 in 1833.

Beneath a canopy of cumulus clouds, Turkey Point Lighthouse was a pastoral spot along the Chesapeake Bay in years past. This photo, taken about 1960, shows the handsome keeper's dwelling and oil shed. Until 1943, the station had no electricity and was illuminated with oil vapor lamps. Today, only the tower stands, powered by solar batteries. Photo courtesy of the U.S. Coast Guard.

The original beacon was a fixed white light illuminated by a series of hollow-wick, whale oil lamps placed in front of silvered reflectors. They produced a foul odor and considerable soot, which had to be cleaned off the globes, reflectors, and lantern windows each day. Even at their most brilliant, the lamps shone only a few miles.

The first keeper of the light, Robert Lusby, augmented his meager income with fishing, hunting, and farming. When he died in 1844, his wife was given the lighthouse job. Elizabeth Lusby, the first of several widows to serve at Turkey Point, remained on duty 18 years, but her record is checkered with reports of hardship and discontent.

In 1853 Mrs. Lusby's pay was suspended by the district inspector because she could not account for the

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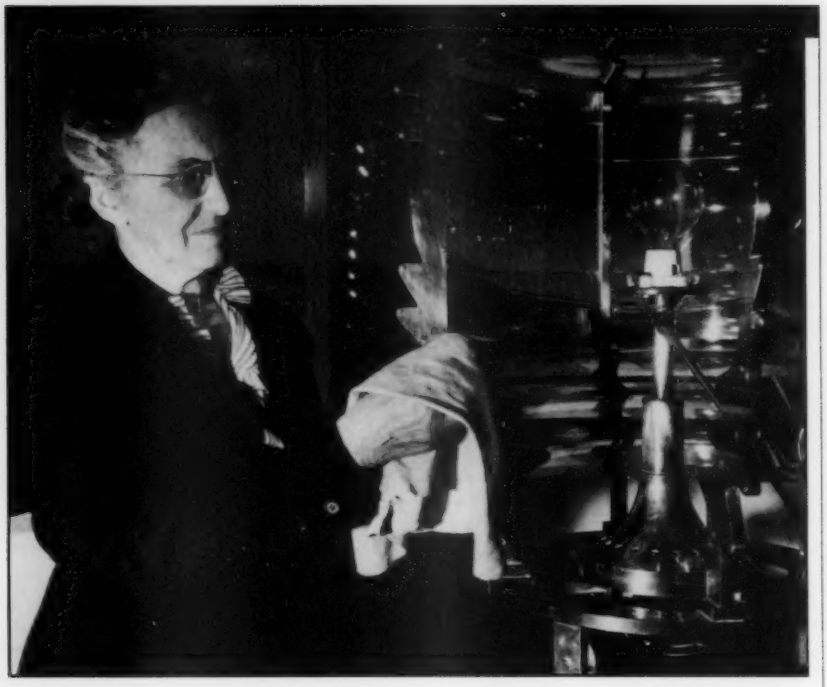

Fanny Salter, the last civilian woman to keep a lighthouse in the U.S., polished the prism lens at Turkey Point for publicity photos shortly before her retirement in 1947. She was one of several women who served at this lighthouse. Photo courtesy of the U.S. Coast Guard Archives.

Turkey Point Lighthouse

Continued from Page 65

oil allotted to the station. Lightkeepers were required by the Lighthouse Board to meticulously measure the oil and keep a ledger of its use. Mrs. Lusby responded to the inspector's action, saying:

"I have been frequently indisposed and not able to attend to measuring the oil for myself, and those I have to assist me may have carelessly given a lesser quantity than they should."

The beacon was drastically improved in 1856 with the installation of a Fresnel lens. Mrs. Lusby handed over her job to a new keeper in 1862, probably for political reasons. (Most appointments to lighthouses were political favors until the end of the 19th century.) Mr. Crouch, the new keeper, married while at the station, but died in 1873 leaving his wife, Rebecca, to tend the beacon.

During her tenure a second story was added to the keeper's house, and the station received a fogbell, mounted in a tower some 100-feet from the lighthouse. The bell striker was powered by weights that hung from a cable suspended in a well dug 30-feet into the ground. Mrs. Crouch had to wind up the weights every two to three hours during periods of fog. If the striking mechanism failed, she rang the bell by hand.

When Mrs. Crouch died in 1895, Georgiana Brumfield, the daughter of a former assistant keeper, was appointed keeper and served a long career of 28 years. The Salter family then came to keep the lighthouse from Virginia's remote ocean light station at Hog Island. Tranquil and protected Turkey Point must have seemed like heaven after such a difficult assignment.

Harry Salter served only two years before he died suddenly. Fanny Salter, then 42 years old with three children to raise, applied for the keeper's job. She was denied because the local district manager felt her age and role as a mother would prevent her from doing a satisfactory job. She wrote to her senator, who appealed to President Coolidge. She got the job largely because Turkey Point required no heavy work and still operated its old oil lamps. Electrification of the station did not occur until 1943.

Fanny Salter became a legend of sorts in the Chesapeake Bay. She had a flawless record and drew media attention when she remained on duty even after the Coast Guard assumed control of lighthouses in 1939. Newspapers dubbed her the "last lady lightkeeper." She was interviewed and photographed on numerous occasions and remained a national curiosity until her retirement at age 64.

A reporter for the Baltimore Sun trekked out to Turkey Point in October 1946 and was greeted by a barking Chesapeake Bay retriever named Lassie. He found Fanny and her son in a pastoral scene tending the livestock—chickens, turkeys, sheep, and horses. Fanny hand-fed a bottle of milk to an orphan lamb while being interviewed.

She told of teaching herself to operate the radio telephone the Coast Guard

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Great Lakes Wrecks

The Milwaukee

Skip Gillham

For most of this century ferries have shuttled rail cars across the different Great Lakes or their connecting channels. Nowhere was this type of ship more popular than on Lake Michigan, where several companies provided service between ports in Michigan and Wisconsin. But this era ended in recent years and the stately ships are mainly a memory. Only BADGER survives in operation and she now handles automobiles and passengers. Several others are idle.

With year 'round rail service there were casualties. One of the worst was the loss of the MILWAUKEE on October 22, 1929.

This 358-foot-long vessel was launched in December 1902 and went to work the next year as MANISTIQUE, MARQUETTE AND NORTHERN NO. 1 for the railway of the same name. The line went bankrupt in November 1903 and the ship was taken over by the Pere Marquette Railroad.

Photo courtesy of the Milwaukee public Library.

It was operated on several routes and sank at the dock in Manistique on January 5, 1908, after being holed by ice off the port. Following repairs, the steel hulled steamer went back to work and by the end of the year had become the MILWAUKEE for the Grand Trunk Railroad and service between Grand Haven and Milwaukee.

MILWAUKEE was hauling a reported 25 freight cars on the eastbound leg when it got caught in a gale and began taking water. The Captain tried to return to Milwaukee but he did not make it. The stern sea gate was damaged by the pounding waves and the pumps could not keep up with the influx of water. MILWAUKEE went down with all hands. Accounts vary on the number of casualties with estimates between 46 and 53. The financial loss was noted at $720,000.

As a result of the disaster, the height of the seagate was raised to 8 feet, 6 inches on car ferries, hoping to prevent a similar accident.

The final resting place remained a mystery for many years but now has been solved. Fishermen snagged their nets on what proved to be the hull of MILWAUKEE in 1963. Divers identified the ship in 1972; it is upright in 200 feet of water.⚓

Turkey Point Lighthouse

Continued from Page 66

had installed in 1942, of a tornado that hit the point in 1944, depositing a layer of clay on the upstairs windows of her house and leveling a barn near the station. She spoke of her hesitance to take vacations because the relief lightkeeper might not do an acceptable job.

When Fanny Salter retired in 1948, the lighthouse was converted to automatic operation and the old keeper's house was closed up. Unfortunately, the loneliness of the station attracted vandals. The valuable, antique lens was stolen in the 1960s and the lantern panes were broken. To prevent further damage, the Coast Guard tore down the old keeper's dwelling and removed part of the tower's spiral stairway. The entry door was securely padlocked, a modern aero-marine beacon was installed, and acrylic storm panes replaced the old glass lantern windows.

Today the lighthouse sits within Elk Neck State Park and is heavily visited by hikers. Only the tower remains, but a careful inspection of the grounds will reveal the old house foundation and the covered well where the fogbell tower once stood. The beacon operates automatically and contains a red sector to cover the mouth of the Susquehanna River. The light is visible up to 8 miles and is powered by solar batteries.⚓

John Ericsson

Dina B. Hill
Education Coordinator
Monitor National Marine Sanctuary

John Ericsson is well known for his design and construction of the Civil War ironclad USS *Monitor*. However, Ericsson's genius manifested itself in many inventions related to ships and the sea.

Ericsson was born in Langbanshyttan in the county of Vermlan, Sweden, on July 31, 1803. In his early years Ericsson showed a keen aptitude for mechanical drawing. At the age of nine he became a Cadet in the Mechanical Corps of the Swedish Navy with engineering duties in mapping of a canal. At twelve he became a surveyor for the canal; by fifteen he was appointed assistant to the Chief Engineer. At seventeen he commissioned as an Ensign in the 23rd Regiment Rifle Corps and became interested in artillery. He also began experimenting with his caloric engine and later with hot air and compressed air engines.

He patented forced draft blowers, tubular boilers, and exhaust steam condensers, and began significant improvements in the operation of steam propulsion. Many of his inventions were used in non-maritime capacities, including fire engines and locomotives.

At age 30, Ericsson was still improving his caloric engine and employing an "equipoise" or balanced rudder of his own design. In about 1840 he patented a screw propeller and subsequently patented several improvements on his design. Also during this period he designed the 954-ton ship *Princeton*, which was launched in 1843. The *Princeton* was the world's first screw steam man-of-war and featured Ericsson's vibrating lever engine.

In 1851, Ericsson presented a number of inventions at the London Exhibition including a distance measuring instrument for use at sea, a hydrostatic gauge, a water-pipe flow gauge, and an alarm barometer.

Ericsson was also working on a design for an armored battery capable of destroying wooden warships while withstanding heavy shot and shell. In 1854 he submitted a design for such a battery to Emperor Napoleon but the battery was never built. When the American Civil War broke out and the Union sought designs for warships that could be built quickly, Ericsson submitted a design for the vessel that would become possibly the most famous ship in American history: the USS *Monitor*. The *Monitor*, designed for river and harbor defense, had a draft of approximately 9 feet. Ericsson included several unique features in his ship: a very low profile, a 5-foot-high, 3-foot-wide "shelf" or armor belt, and a revolving gun turret. In essence the *Monitor* was the ancestor of battleships used in modern warfare. She was also the prototype for other "monitors," all low-profile, armored and turreted vessels including some double-turreted, ocean-going ships. Incorporated into the *Monitor* were several of Ericsson's inventions. These included a sounding device "based upon the compression of the air contained within it, by the pressure of the sea, which for each succeeding fathom in depth increases in a practically considered direct ratio;" an anchor-hoisting mechanism that permitted the raising and lowering of the anchor without exposing men to enemy fire; and the first flushing marine toilet.

After the Civil War Ericsson designed a light gunboat for defense of Sweden's shoreline. The monitor design was used throughout Scandinavia as well as in England and Russia. Monitors were used in the United States until after the turn of the century, when many were sold to South America.

Ericsson continued to improve upon his designs and to produce new inventions. His primary interest was in propulsion systems as demonstrated by many of his inventions and improvements. Unshrouded screws, twin screws, and counter-rotating screws as well as four-bladed propellers and depth gauges were but some of Ericsson's successes in a career that spanned nearly seven decades. Ericsson's friend and biographer William Conant Church said of him, "With his great mental power and intense nervous force were combined enormous muscular strength and corresponding physical passion. He was...in every respect a high-pressure engine."

Ericsson died on March 8, 1889 in New York, and in 1890 his body was transported to Sweden. Former crewmen from the *Monitor* accompanied the casket down the dock and U.S. warships fired salutes as the ship carrying Ericsson's body began its journey. These warships bore the mark of Ericsson's brilliance and foresight, as would warships for generations to come.⚓

VOS Cooperative Ship Reports

The tables for the VOS reports are compiled by the National Climatic Data Center from radio messages and weather logs. Forms are counted in the monthly totals for each ship when it is received at the NCDC; normally within 60 days from the end of a data month. The three columns under manuscript heading "RECEIVED" denote if a form was received for that month or not. Data received late are not counted, but are still entered into the data base. Some ships may show 100% radio observations, but show forms were also received. This occurs when the mail and radio observations are duplicated. Only the radio message was entered into the data base.

The names of ships listed are from the list of vessels supplied by the Port Meteorological Officers(PMOs) to the NCDC. Comments or questions regarding this report should be directed to NCDC, Operations Support Division, 151 Patton Ave, Asheville, NC 28801 attn: Dimitri Chappas (phone: 704-271-4437 or e-mail: dchappas@ncdc.noaa.gov).

January - March 1996

NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
1ST LT BALDOMERO LOPEZ	18	100.0	N	N	N
1ST LT JACK LUMMUS	46	100.0	N	N	N
2ND LT. JOHN P. BOBO	29	89.6	Y	Y	Y
A. V. KASTNER	79	100.0	N	N	N
ABITIBI ORINOCO	15	100.0	N	N	N
ACACIA	15	100.0	Y	N	N
ACADIA FOREST	201	43.7	Y	Y	Y
ACT 7	173	100.0	N	N	N
ACT I	179	100.0	N	N	N
ADABELLE LYKES	89	50.5	Y	Y	Y
ADAM E. CORNELIUS	16	12.5	N	N	N
ADDIRIYAH	102	0.0	Y	Y	Y
ADVANTAGE	77	94.8	Y	Y	Y
AFRIC STAR	33	100.0	N	N	N
AGDLEK	79	100.0	N	N	N
AGULHAS	131	90.0	Y	Y	Y
AL AWDAH	25	100.0	N	N	N
AL SAMIDOON	237	100.0	N	N	N
AL SHUHADAA	143	100.0	N	N	N
ALASKA	30	96.6	Y	Y	N
ALBATROS	20	100.0	N	N	N
ALBEMARLE ISLAND	56	92.8	N	N	N
ALBERNI DAWN	201	100.0	N	N	N
ALDEN W. CLAUSEN	11	100.0	N	N	N
ALEXANDER VON HUMBOLD	771	100.0	N	N	N
ALLIGATOR AMERICA	67	100.0	N	N	N
ALLIGATOR BRAVERY	162	88.8	Y	Y	Y
ALLIGATOR COLUMBUS	94	76.5	Y	Y	Y
ALLIGATOR EXCELLENCE	76	96.0	Y	N	N
ALLIGATOR FORTUNE	29	100.0	N	N	N
ALLIGATOR GLORY	54	100.0	N	N	N
ALLIGATOR JOY	22	100.0	Y	N	N
ALLIGATOR LIBERTY	166	100.0	N	N	N
ALLIGATOR STRENGTH	174	64.3	Y	Y	Y
ALMANIA	34	85.2	N	N	N
ALPENA	3	100.0	Y	N	N
ALPHA HELIX	194	67.0	Y	Y	Y
ALTAIR	851	100.0	N	N	N
ALTAMONTE	17	100.0	Y	N	N
AMALIA	70	32.8	N	N	N
AMAZON	105	86.6	Y	Y	Y
AMBASSADOR	50	74.0	Y	Y	Y
AMBASSADOR BRIDGE	6	100.0	N	N	N
AMER HIMALAYA	92	100.0	N	N	N
AMERICA STAR	184	100.0	N	N	N
AMERICAN CONDOR	147	0.0	Y	Y	Y
AMERICAN CORMORANT	18	100.0	N	N	N
AMERICAN FALCON	40	55.0	N	N	N
AMERICAN OSPREY	12	100.0	N	N	N
AMERICANA	37	97.2	Y	Y	Y
AMERIGO VESPUCCI	97	44.3	Y	Y	Y
AMKE	2	100.0	N	N	N
ANASTASIS	33	100.0	N	N	N
ANATOLIY KOLESNICHENKO	7	100.0	N	N	N
ANDERS MAERSK	183	54.6	Y	Y	Y
ANNA MAERSK	192	54.6	Y	Y	Y
ANTWERPEN	76	100.0	N	N	N
APL CHINA	68	64.7	N	N	N
APL PHILIPPINES	59	0.0	N	N	N
APL THAILAND	5	100.0	N	N	N
AQIPIITTUK	1	100.0	N	N	N
ARABELLA	205	22.4	Y	Y	Y
ARABIAN SEA	38	39.4	Y	Y	Y
ARABIAN SENATOR	81	100.0	N	N	N
ARCO ALASKA	46	34.7	Y	Y	Y
ARCO CALIFORNIA	70	0.0	Y	Y	Y
ARCO FAIRBANKS	38	86.8	Y	Y	Y
ARCO INDEPENDENCE	52	63.4	Y	Y	Y
ARCO JUNEAU	8	50.0	Y	N	N
ARCO SPIRIT	36	0.0	Y	Y	N
ARCO TEXAS	22	27.2	N	N	N
ARCTIC OCEAN	51	98.0	Y	Y	Y
ARCTIC SUN	105	21.9	Y	Y	Y
ARCTIC UNIVERSAL	154	100.0	N	N	N
ARDMORE	18	100.0	N	N	N
ARGONAUT	104	42.3	Y	Y	Y
ARINA ARCTICA	119	100.0	N	N	N
ARIZONA	26	100.0	N	N	N
ARKONA	66	106.0	N	N	N
ARKTIS LIGHT	205	91.7	Y	Y	Y
ARTHUR M. ANDERSON	25	84.0	N	N	N
ARTHUR MAERSK	191	90.0	Y	Y	Y
ASIAN CHALLENGER	19	100.0	N	N	N
ASIAN SENATOR	37	100.0	N	N	N
ASIMONT	117	100.0	N	N	N
ASTRO MERCURY	47	85.1	N	N	N
ATLANTA BAY	33	100.0	N	N	N
ATLANTIC	683	100.0	N	N	N
ATLANTIC BULKER	56	0.0	Y	N	N
ATLANTIC CARTIER	3	100.0	N	N	N
ATLANTIC COMPASS	109	100.0	N	N	N
ATLANTIC COMPANION	59	100.0	N	N	N
ATLANTIC CONCERT	62	100.0	N	N	N
ATLANTIC CONVEYOR	24	100.0	N	N	N
ATLANTIC ERIE	33	100.0	N	N	N

Continued on Page 70

VOS Cooperative Ship Reports (Continued from Page 69)

NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
ATLANTIC HURON	86	100.0	N	N	N
ATLANTIC OCEAN	33	96.9	N	N	N
ATLANTIC SUPERIOR	129	100.0	N	N	N
AUCKLAND STAR	33	100.0	N	N	N
AUSTRAL RAINBOW	15	33.3	Y	Y	N
AUTHOR	101	100.0	N	N	N
AVILA STAR	40	100.0	N	N	N
AXEL MAERSK	194	48.4	Y	Y	Y
B.T. ALASKA	91	47.2	Y	Y	Y
BACO-LINER 1	141	100.0	N	N	N
BACO-LINER 2	131	100.0	N	N	N
BACO-LINER 3	200	100.0	N	N	N
BAR' ZAN	40	100.0	N	N	N
BARBICAN SPIRIT	49	100.0	N	N	N
BARRINGTON ISLAND	22	100.0	N	N	N
BAUCHI	121	76.8	Y	Y	Y
BAY BRIDGE	132	16.6	Y	Y	Y
BELGRANO	88	64.7	Y	Y	N
BELLONA	141	98.5	N	N	N
BERGEN ARROW	4	100.0	N	N	N
BERING SEA	123	82.1	Y	Y	Y
BERNARDO QUINTANA A	201	90.5	Y	Y	Y
BESKYTTEREN	203	100.0	N	N	N
BLEST FUTURE	104	100.0	N	N	N
BLIKUR	63	100.0	N	N	N
BLUE RIDGE	85	76.4	Y	Y	Y
BOGASARI LIMA	69	100.0	N	N	N
BOHINJ	175	19.4	N	N	N
BONN EXPRESS	330	100.0	N	N	N
BOSPORUS BRIDGE	133	100.0	N	N	N
BOW TRIGGER	12	100.0	N	N	N
BP ADMIRAL	211	100.0	N	N	N
BP ADVENTURE	126	100.0	N	N	N
BREMEN EXPRESS	20	100.0	N	N	N
BRISBANE STAR	203	100.0	N	N	N
BRITISH RANGER	289	100.0	N	N	N
BROOKLYN BRIDGE	193	98.9	Y	Y	Y
BRUCE SMART	127	18.1	Y	Y	Y
BT NAUTILUS	16	100.0	N	N	N
BUCKEYE	16	93.7	Y	N	N
BUFFALO SOLDIER	4	100.0	N	N	N
BUNGA SAGA TIGA	87	90.8	Y	Y	Y
BURNS HARBOR	53	81.1	Y	N	N
BURSA	5	100.0	N	N	N
C.S. IRIS	9	100.0	N	N	N
CALIFORNIA CERES	29	100.0	N	N	N
CALIFORNIA CURRENT	127	100.0	N	N	N
CALIFORNIA HERMES	263	15.2	Y	Y	Y
CALIFORNIA LUNA	91	100.0	N	N	N
CALIFORNIA MERCURY	207	100.0	N	N	N
CALIFORNIA ORION	150	65.3	Y	Y	Y
CALIFORNIA PEGASUS	41	100.0	N	N	N
CALIFORNIA SATURN	43	100.0	N	N	N
CALIFORNIA STAR	2	100.0	N	N	N
CALIFORNIA TRITON	94	87.2	N	N	N
CALIFORNIA ZEUS	32	100.0	N	N	N
CANADIAN LIBERTY	52	100.0	N	N	N
CAPE BREEZE	157	93.6	Y	Y	Y
CAPE CHARLES	88	100.0	N	N	N
CAPE HENRY	42	100.0	N	N	N
CAPE INTREPID	11	100.0	N	N	N
CAPE MAY	114	100.0	N	N	N
CAPE RISE	13	84.6	N	N	N
CARIBBEAN MERCY	8	100.0	Y	Y	N
CARLA A. HILLS	182	83.5	N	N	N
CARMEL	96	17.7	Y	Y	Y
CAROLINA	15	20.0	Y	N	N
CAROLINE OLDENDORFF	97	96.9	Y	N	N
CASON J. CALLAWAY	23	100.0	Y	N	N
CASTOR	30	96.6	Y	N	N
CCNI ATACAMA	94	90.4	Y	Y	Y
CELEBRATION	126	50.0	Y	Y	Y
CENTURY HIGHWAY #2	80	100.0	N	N	N
CENTURY HIGHWAY NO. 1	55	100.0	N	N	N
CENTURY HIGHWAY NO. 5	36	100.0	N	N	N
CENTURY HIGHWAY_NO. 3	91	100.0	N	N	N
CENTURY LEADER NO. 1	105	100.0	N	N	N
CHARLES ISLAND	128	93.7	Y	Y	Y
CHARLES LYKES	102	100.0	N	N	N
CHARLES M. BEEGHLEY	12	100.0	N	N	N
CHARLESTON	1	100.0	N	N	N
CHARLOTTE MAERSK	24	0.0	N	N	N
CHASTINE MAERSK	80	78.7	Y	Y	Y
CHC NO.1	53	100.0	N	N	N
CHEMICAL PIONEER	133	90.2	N	N	N
CHEMICAL RUBI	34	100.0	N	N	N
CHESAPEAKE BAY	71	100.0	N	N	N
CHESAPEAKE TRADER	5	100.0	N	N	N
CHEVRON ARIZONA	92	63.0	Y	Y	Y
CHEVRON ATLANTIC	75	0.0	Y	N	N
CHEVRON COLORADO	91	83.5	Y	Y	N
CHEVRON EDINBURGH	162	63.5	Y	Y	Y
CHEVRON EMPLOYEE PRIDE	134	2.2	Y	Y	Y
CHEVRON FELUY	118	0.0	Y	Y	Y
CHEVRON MISSISSIPPI	48	68.7	Y	Y	Y
CHEVRON PACIFIC	172	38.3	Y	Y	Y
CHEVRON PERTH	19	100.0	N	N	N
CHEVRON SOUTH AMERICA	156	45.5	Y	Y	Y
CHEVRON WASHINGTON	7	14.2	N	N	N
CHIEF GADAO	49	93.8	Y	Y	Y
CHILEAN EXPRESS	35	100.0	N	N	N
CHILEAN REEFER	1	100.0	N	N	N
CHINA HOPE	63	100.0	N	N	N
CHINA SPIRIT	34	100.0	N	N	N
CHIQUITA BELGIE	147	100.0	N	N	N
CHIQUITA BOCAS	136	100.0	N	N	N
CHIQUITA DEUTSCHLAND	179	100.0	N	N	N
CHIQUITA ITALIA	130	100.0	N	N	N
CHIQUITA JEAN	175	100.0	N	N	N
CHIQUITA NEDERLAND	148	100.0	N	N	N
CHIQUITA SCANDINAVIA	154	100.0	N	N	N
CHIQUITA SCHWEIZ	195	100.0	N	N	N
CHOYANG PRIDE	74	100.0	N	N	N
CHRISTIANE	86	91.8	N	N	N
CIELO DI FIRENZE	14	100.0	N	N	N
CITY OF DURBAN	180	100.0	N	N	N
CLEVELAND	45	55.5	Y	N	N
CLIFFORD MAERSK	121	83.4	Y	Y	Y
CMS ISLAND EXPRESS	55	0.0	Y	Y	Y
COAST RANGE	29	68.9	Y	N	N
COLORADO	19	100.0	N	N	N
COLUMBIA BAY	105	100.0	N	N	N
COLUMBIA STAR	209	100.0	N	N	N
COLUMBINE	219	95.8	Y	N	N
COLUMBUS AMERICA	52	100.0	N	N	N
COLUMBUS AUSTRALIA	28	100.0	N	N	N
COLUMBUS CALIFORNIA	195	100.0	N	N	N
COLUMBUS CANADA	133	100.0	N	N	N
COLUMBUS NEW ZEALAND	52	100.0	N	N	N
COLUMBUS OLIVOS	55	61.8	N	N	N
COLUMBUS VICTORIA	183	100.0	N	N	N
CONDOLEEZZA RICE	51	23.5	Y	N	N
CONTIENTAL WING	103	100.0	N	N	N
CONTSHIP AMERICA	32	100.0	N	N	N
CORMORANT ARROW	133	54.8	Y	Y	Y
CORNELIA MAERSK	98	96.9	Y	Y	N
CORNELIS VEROLME	4	100.0	N	N	N
CORNUCOPIA	103	75.7	Y	Y	Y

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NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
CORONADO	1	100.0	N	N	N
CORPUS CHRISTI	20	100.0	N	N	N
CORWITH CRAMER	12	58.3	N	N	N
COSMIC CHALLENGER	56	0.0	N	N	N
COSMIC MASTER	56	89.2	N	N	N
COURAGEOUS	3	0.0	Y	N	N
COURIER	29	100.0	N	N	N
COURTNEY BURTON	21	100.0	N	N	N
COURTNEY L	189	85.7	Y	Y	Y
CRANE PACIFIC	75	94.6	N	N	N
CRISTOFORO COLOMBO	88	48.8	Y	Y	Y
CROWN OF SCANDINAVIA	191	100.0	N	N	N
CROWN PRINCESS	2	100.0	N	N	N
CSK UNITY	64	96.8	Y	Y	Y
CSL ATLAS	57	100.0	N	N	N
CSL CABO	85	100.0	N	N	N
DANIA PORTLAND	126	100.0	N	N	N
DAVID Z. NORTON	8	87.5	Y	N	N
DEL MONTE PACKER	59	91.5	N	N	N
DEL MONTE TRADER	99	52.5	Y	Y	Y
DELAWARE TRADER	336	92.5	Y	Y	Y
DELMONTE PLANTER	92	88.0	Y	Y	Y
DELMONTE TRANSPORTER	90	74.4	Y	Y	Y
DENALI	129	88.3	Y	Y	N
DEPPE FLORIDA	240	100.0	N	N	N
DG COLUMBIA	221	86.4	Y	Y	Y
DIRECT EAGLE	78	100.0	N	N	N
DIRECT FALCON	189	82.5	Y	Y	Y
DIRECT KEA	94	100.0	N	N	N
DIRECT KIWI	201	100.0	N	N	N
DIRECT KOOKABURRA	119	100.0	N	N	N
DOCK EXPRESS 10	90	100.0	N	N	N
DOCK EXPRESS 20	153	100.0	N	N	N
DOLPHIN IV	2	100.0	N	N	N
DONAU ORE	34	91.1	N	N	N
DOROTHEA OLDENDORFF	74	86.4	Y	N	N
DOUBLE GLORY	55	90.9	Y	Y	Y
DRAGON	112	0.0	Y	Y	Y
DRYSO	5	100.0	N	N	N
DSR BALTIC	151	100.0	N	N	N
DSR EUROPE	118	100.0	N	N	N
DSR PACIFIC	67	100.0	N	N	N
DUBROVNIK EXPRESS	31	100.0	N	N	N
DUCHESS	43	41.8	N	N	N
DUNCAN ISLAND	156	94.8	Y	Y	Y
DUSSELDORF EXPRESS	507	100.0	N	N	N
EASTERN LION	247	100.0	N	N	N
EASTWIND	4	100.0	N	N	N
ECSTASY	1	100.0	N	N	N
EDELWIESS	82	100.0	N	N	N
EDGAR B. SPEER	8	87.5	Y	N	N
EDWIN H. GOTT	40	87.5	Y	N	N
EDYTH L	95	91.5	Y	Y	Y
ELENORE	25	100.0	N	N	N
ELISE SHULTE	56	0.0	N	N	N
ELLEN KNUDSEN	37	70.2	Y	Y	Y
ELLENSBORG	20	0.0	Y	N	N
ELSBERG	209	23.4	Y	Y	Y
ENIF	64	100.0	N	N	N
EVER GAINING	27	55.5	Y	Y	N
EVER GARLAND	6	100.0	N	N	N
EVER GATHER	19	100.0	N	N	N
EVER GENIUS	11	81.8	N	N	N
EVER GENTLE	4	100.0	N	N	N
EVER GENTRY	3	100.0	N	N	N
EVER GIVEN	32	100.0	N	N	N
EVER GLAMOUR	31	100.0	N	N	N
EVER GLEAMY	22	90.9	Y	N	N
EVER GLEEFUL	15	66.6	Y	N	N
EVER GLOBE	28	100.0	N	N	N
EVER GLORY	5	100.0	N	N	N
EVER GOING	17	100.0	N	N	N
EVER GOLDEN	14	100.0	N	N	N
EVER GRACE	10	100.0	N	N	N
EVER GRADE	14	100.0	N	N	N
EVER GROWTH	20	70.0	Y	Y	N
EVER GUARD	8	87.5	Y	Y	N
EVER LAUREL	31	100.0	N	N	N
EVER RACER	1	0.0	N	N	N
EVER REFINE	13	100.0	N	N	N
EVER RENOWN	3	100.0	N	N	N
EVER RESULT	65	80.0	Y	Y	Y
EVER ROUND	77	42.8	Y	Y	Y
EVER ROYAL	40	25.0	Y	N	N
EWA	1	100.0	N	N	N
EXCELSIOR	239	98.3	Y	Y	Y
EXEMPLAR	250	100.0	N	N	N
EXPORT FREEDOM	75	34.6	N	N	N
EXPORT PATRIOT	119	52.1	Y	Y	Y
FAIRLIFT	75	100.0	N	N	N
FAIRMAST	2	100.0	N	N	N
FALSTER	21	100.0	N	N	N
FALSTRIA	183	100.0	N	N	N
FANTASY	12	91.6	N	N	N
FARALLON ISLAND	56	100.0	N	N	N
FASCINATION	64	90.6	Y	Y	Y
FATHULKHAIR	50	18.0	Y	Y	N
FAUST	144	52.0	Y	Y	Y
FERNCROFT	100	72.0	N	N	N
FETISH	158	96.8	N	N	N
FIDELIO	119	52.1	N	N	N
FIORA TOPIC	10	100.0	N	N	N
FIR GROVE	41	100.0	N	N	N
FLAMENGO	70	45.7	Y	N	N
FLORAL LAKE	33	100.0	N	N	N
FOREST CHAMPION	6	100.0	N	N	N
FOREST HAWK	40	67.5	Y	N	N
FRANCES HAMMER	149	100.0	N	N	N
FRANCES L	96	89.5	Y	Y	Y
FRED R. WHITE JR	8	100.0	Y	N	N
FREJA SVEA	26	88.4	N	N	N
FULL COMFORT	80	97.5	N	N	N
GALVESTON BAY	169	92.3	N	N	N
GEORGE A. STINSON	13	100.0	N	N	N
GEORGE H. WEYERHAEUSER	230	44.3	Y	Y	Y
GEORGE SCHULTZ	110	55.4	Y	Y	Y
GEORGE WASHINGTON BRID	167	98.8	Y	Y	Y
GEORGIA RAINBOW II	122	100.0	N	N	N
GERMAN SENATOR	43	100.0	N	N	N
GLOBAL LINK	51	33.3	Y	Y	N
GLOBAL MARINER	24	91.6	N	N	N
GLORIOUS SUN	128	94.5	Y	Y	Y
GOLDEN APO	34	91.1	Y	N	N
GOLDEN GATE	19	36.8	Y	N	N
GOLDEN GATE BRIDGE	142	66.9	Y	Y	Y
GOPHER STATE	45	71.1	Y	N	N
GREAT LAKE	6	100.0	N	N	N
GREAT LAND	97	46.3	Y	Y	Y
GREEN BAY	66	100.0	N	N	N
GREEN HARBOUR	3	33.3	Y	N	N
GREEN ISLAND	53	56.6	N	N	N
GREEN LAKE	52	100.0	Y	N	N
GREEN MAYA	39	100.0	N	N	N
GREEN RAINIER	48	83.3	Y	N	N
GREEN RIDGE	38	97.3	Y	N	N
GREEN SASEBO	51	47.0	Y	Y	Y
GREEN SUMA	182	10.9	Y	Y	Y
GROTON	115	83.4	Y	Y	Y

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VOS Cooperative Ship Reports (Continued from Page 71)

NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
GROWTH RING	113	100.0	N	N	N
GUANAJUATO	92	33.6	N	N	N
GUAYAMA	183	54.0	Y	Y	Y
GULF CURRENT	257	93.3	Y	Y	Y
GULF SPIRIT	7	100.0	N	N	N
GULL ARROW	60	100.0	N	N	N
GYPSUM BARON	105	100.0	N	N	N
GYPSUM KING	92	100.0	N	N	N
HAKONE MARU	17	100.0	N	N	N
HAKUFU	11	100.0	N	N	N
HANDY BRAVE	49	18.3	Y	N	N
HANDY LOGGER	89	76.4	Y	Y	Y
HANJIN BARCELONA	31	96.7	Y	Y	N
HANJIN CHUNGMU	15	100.0	N	N	N
HANJIN COLOMBO	34	100.0	N	N	N
HANJIN ELIZABETH	14	100.0	N	N	N
HANJIN FELIXSTOWE	1	100.0	N	N	N
HANJIN HONG KONG	35	100.0	N	N	N
HANJIN KAOHSIUNG	14	100.0	N	N	N
HANJIN KEELUNG	9	100.0	N	N	N
HANJIN LONG BEACH	17	100.0	N	N	N
HANJIN MARSEILLES	40	100.0	N	N	N
HANJIN NEW YORK	27	100.0	N	N	N
HANJIN OAKLAND	18	100.0	N	N	N
HANJIN ROTTERDAM	14	100.0	N	N	N
HANJIN SEATTLE	59	49.1	Y	Y	N
HANJIN SHANGHAI	27	100.0	N	N	N
HANJIN TOKYO	41	100.0	N	N	N
HANJIN TONGHAE	31	100.0	N	N	N
HANJIN VANCOUVER	12	100.0	N	N	N
HANJIN YOKOHAMA	59	100.0	N	N	N
HANSA LUBECK	48	100.0	N	N	N
HARBOUR BRIDGE	162	66.6	Y	Y	Y
HARMONY ACE	74	100.0	N	N	N
HAVELLAND	137	59.8	Y	Y	Y
HEICON	161	44.0	Y	Y	Y
HEIDELBERG EXPRESS	891	100.0	N	N	N
HELVETIA	2	100.0	N	N	N
HENRY HUDSON BRIDGE	225	100.0	N	N	N
HERMOD	46	100.0	N	N	N
HESIOD	67	100.0	N	N	N
HG-7 NIELS JENSEN	102	100.0	N	N	N
HIGHGATE	102	100.0	N	N	N
HOEGH CAIRN	13	92.3	Y	N	N
HOEGH CLIPPER	18	100.0	N	N	N
HOEGH DRAKE	6	33.3	N	N	N
HOEGH DUKE	24	100.0	N	N	N
HOEGH DYKE	6	100.0	N	N	N
HOEGH MERIT	43	34.8	N	N	N
HOEGH MINERVA	188	21.8	Y	Y	Y
HORIZON	210	1.4	Y	Y	Y
HOWELL LYKES	86	40.6	Y	Y	Y
HUAL INGRITA	6	100.0	N	N	N
HUMACAO	181	40.3	Y	Y	Y
HVIDBJORNEN	62	100.0	N	N	N
HYUNDAI DUKE	26	100.0	Y	N	N
HYUNDAI EMPEROR	25	100.0	N	N	N
HYUNDAI LONGVIEW	158	92.4	Y	Y	N
HYUNDAI TACOMA	147	87.7	Y	Y	Y
HYUNDAI VANCOUVER	2	100.0	N	N	N
IGARKA	36	100.0	N	N	N
IMAGINATION	75	89.3	Y	Y	Y
INDIAN OCEAN	50	94.0	Y	Y	Y
INDIANA HARBOR	14	78.5	Y	N	N
INGER-C	55	96.3	N	N	N
INSPIRATION	36	63.8	N	N	N
IOWA TRADER	69	100.0	N	N	N
IRENA ARCTICA	264	100.0	N	N	N
ISLA GRAN MALVINA	36	72.2	N	N	N
ISLAND BREEZE	94	0.0	Y	Y	Y
ISLAND PRINCESS	7	100.0	N	N	N
ITB BALTIMORE	57	84.2	N	N	N
ITB MOBILE	82	92.6	Y	Y	Y
ITB NEW YORK	77	0.0	Y	Y	Y
IVER EXPLORER	16	100.0	N	N	N
IVER EXPRESS	12	100.0	N	N	N
IWANUMA MARU	253	22.5	Y	Y	Y
J. DENNIS BONNEY	83	71.0	Y	Y	Y
JACKSONVILLE	194	93.8	Y	Y	Y
JADE PACIFIC	29	100.0	N	N	N
JAHRE SPIRIT	30	100.0	N	N	N
JALAGOVIND	11	100.0	N	N	N
JAMES LYKES	58	100.0	N	N	N
JAPAN RAINBOW 2	138	58.6	N	N	N
JAPAN SENATOR	75	100.0	N	N	N
JASMINE	25	100.0	N	N	N
JEAN LYKES	147	51.7	Y	Y	Y
JEBEL ALI	75	69.3	Y	Y	Y
JENS KOFOED	16	100.0	N	N	N
JO CLIPPER	34	100.0	N	N	N
JO ELM	83	100.0	N	N	N
JOHN G. MUNSON	23	69.5	Y	N	N
JOHN J. BOLAND	11	63.6	Y	N	N
JOHN YOUNG	150	0.0	Y	Y	Y
JOSEPH L. BLOCK	7	85.7	Y	N	N
JOSEPH LYKES	14	100.0	N	N	N
JUBILANT	20	0.0	N	N	N
JULIUS HAMMER	79	100.0	N	N	N
JUPITER DIAMOND	46	100.0	N	N	N
KAIJIN	129	95.3	Y	Y	Y
KAKUSHIMA	26	100.0	N	N	N
KALIDAS	1	100.0	N	N	N
KAPITAN BOCHEK	10	100.0	N	N	N
KAPITAN BYANKIN	200	87.5	Y	Y	Y
KAPITAN GNEZPILOV	73	100.0	N	N	N
KAPITAN KONEV	208	87.9	Y	Y	Y
KAPITAN MAN	35	100.0	N	N	N
KAPITAN SERYKH	131	80.9	Y	N	N
KAUAI	154	66.8	Y	Y	Y
KAZIMAH	125	100.0	N	N	N
KEE LUNG	37	100.0	N	N	N
KENAI	31	100.0	N	N	N
KENNETH E. HILL	101	76.2	Y	Y	Y
KENNETH T. DERR	53	75.4	Y	Y	Y
KISTA ARCTICA	73	100.0	N	N	N
KITTANING	87	82.7	N	N	N
KNOCK ALLAN	154	100.0	N	N	N
KNORR	35	100.0	N	N	N
KOELN EXPRESS	276	100.0	N	N	N
KOMSOMOLETS PRIMORYA	8	100.0	N	N	N
KONSTANTINOS A	49	100.0	N	N	N
KURAMA	60	100.0	N	N	N
KURE	71	74.6	Y	Y	Y
LA TRINITY	133	94.7	Y	Y	Y
LAWRENCE H. GIANELLA	43	69.7	Y	Y	Y
LEE A. TREGURTHA	3	100.0	Y	N	N
LEGEND OF THE SEAS	47	82.9	N	N	N
LEON	2	100.0	N	N	N
LEONARD J. COWLEY	15	100.0	N	N	N
LEONIA	37	100.0	N	N	N
LERMA	31	100.0	N	N	N
LIBERTY SEA	2	100.0	N	N	N
LIBERTY STAR	88	70.4	Y	Y	Y
LIBERTY SUN	50	62.0	N	N	N
LIBERTY VICTORY	169	8.2	N	N	N
LIBERTY WAVE	7	57.1	Y	N	N
LIHUE	87	31.0	Y	Y	Y
LINDA OLDENDORF	110	71.8	N	N	N

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VOS Cooperative Ship Reports (Continued from Page 72)

NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
LIRCAY	212	55.1	Y	Y	Y
LNG AQUARIUS	150	6.6	Y	Y	Y
LNG CAPRICORN	58	60.3	Y	Y	N
LNG LEO	83	46.9	Y	Y	Y
LNG LIBRA	35	100.0	N	N	N
LNG TAURUS	193	56.9	Y	Y	Y
LNG VIRGO	68	61.7	Y	Y	Y
LONDON SPIRIT	123	100.0	N	N	N
LONG BEACH	175	52.5	Y	Y	Y
LONG LINES	23	100.0	N	N	N
LOUISIANA	39	84.6	Y	Y	N
LT ARGOSY	39	100.0	N	N	N
LT PRAGATI	34	100.0	N	N	N
LT. ODYSSEY	11	100.0	N	N	N
LUCKY	53	100.0	N	N	N
LUCKY BULKER	96	100.0	N	N	N
LUCKY GRACE	265	9.8	Y	Y	Y
LUNA MAERSK	130	71.5	Y	Y	Y
LURLINE	190	46.8	Y	Y	Y
M. P. GRACE	2	100.0	N	N	N
MACKINAC BRIDGE	194	98.4	Y	Y	Y
MADISON MAERSK	66	21.2	Y	Y	Y
MAERSK CHARLESTON	30	90.0	Y	Y	N
MAERSK CONSTELLATION	55	70.9	Y	Y	N
MAERSK ENDEAVOUR	475	100.0	N	N	N
MAERSK EXPLORER	532	100.0	N	N	N
MAERSK LA PLATA	132	100.0	N	N	N
MAERSK LIMA	117	83.7	N	N	N
MAERSK SUN	131	100.0	N	N	N
MAERSK TANJONG	88	100.0	N	N	N
MAERSK VANCOUVER	81	0.0	Y	Y	Y
MAERSK YOKOHAMA	47	100.0	N	N	N
MAGIC	86	88.3	N	N	N
MAGLEBY MAERSK	61	42.6	Y	Y	Y
MAHARASHTRA	51	90.1	N	N	N
MAHIMAHI	193	92.2	Y	N	N
MAIRANGI BAY	196	100.0	N	N	N
MAJ STEPHEN W PLESS MP	106	87.7	Y	Y	Y
MAJESTIC MAERSK	113	21.2	Y	Y	Y
MALCOLM BALDRIGE	356	92.9	Y	N	N
MALMNES	93	1.0	N	N	N
MANGAL DESAI	84	100.0	N	N	N
MANHATTAN BRIDGE	83	90.3	N	N	N
MANUKAI	105	44.7	Y	Y	Y
MANULANI	133	54.1	Y	Y	Y
MARCARRIER	66	100.0	N	N	N
MARCHEN MAERSK	86	58.1	Y	Y	Y
MAREN MAERSK	100	11.0	Y	Y	Y
MARGRETHE MAERSK	79	55.6	N	N	N
MARIA LAURA	177	82.4	Y	Y	Y
MARIA TOPIC	66	80.3	Y	N	N
MARIE MAERSK	116	73.2	Y	Y	Y
MARINE EXPRESS	19	100.0	N	N	N
MARINE RELIANCE	45	100.0	N	N	N
MARIT MAERSK	93	54.8	Y	N	N
MARK HANNAH	8	100.0	N	N	N
MARLIN	136	0.0	Y	Y	Y
MARTHA II	14	100.0	N	N	N
MATHILDE MAERSK	105	63.8	Y	Y	Y
MATSONIA	232	56.8	Y	Y	Y
MAUI	208	84.1	Y	Y	Y
MAURICE EWING	186	58.6	Y	Y	Y
MAYAGUEZ	197	51.7	N	N	N
MAYVIEW MAERSK	105	60.0	Y	Y	Y
MC-KINNEY MAERSK	107	85.9	Y	Y	Y
MEARSK NEWARK	101	32.6	N	N	N
MEDALLION	70	87.1	N	N	N
MELBOURNE STAR	89	100.0	N	N	N
MELVILLE	223	82.9	Y	Y	N
MERCANDIAN ARROW	12	0.0	Y	N	N
MERCHANT PREMIER	126	100.0	N	N	N
MERCHANT PRINCE	85	100.0	N	N	N
MERCHANT PRINCIPAL	144	100.0	N	N	N
MERCURY DIAMOND	40	100.0	N	N	N
MERIDA	217	60.8	Y	Y	Y
MERIDIAN	101	0.0	Y	Y	Y
MERLION ACE	192	23.4	Y	Y	Y
MESABI MINER	29	93.1	Y	N	N
METTE MAERSK	54	42.5	Y	Y	N
MICHIGAN	206	32.0	Y	Y	Y
MIDDLETOWN	11	81.8	Y	N	N
MILDBURG	298	100.0	N	N	N
MINERAL OSPREY	31	96.7	N	N	N
MING ASIA	14	100.0	N	N	N
MING PEACE	57	100.0	N	N	N
MING PLEASURE	144	100.0	N	N	N
MING PROPITIOUS	52	100.0	N	N	N
MITLA	96	100.0	N	N	N
MOANA PACIFIC	93	94.6	Y	N	N
MOANA WAVE	51	100.0	N	N	N
MOKIHANA	176	84.0	Y	Y	Y
MOKU PAHU	20	5.0	N	N	N
MONOA	218	25.2	Y	Y	Y
MONTERREY	222	90.5	Y	Y	Y
MORELOS	79	100.0	N	N	N
MORMACSKY	4	100.0	N	N	N
MORMACSTAR	160	30.6	N	N	N
MORMACSUN	74	51.3	Y	Y	Y
MOSEL ORE	150	96.0	Y	Y	Y
MSC MAUREEN	27	81.4	Y	N	N
NAJA ARCTICA	26	100.0	N	N	N
NARA	42	42.8	N	N	N
NATIONAL DIGNITY	40	97.5	Y	Y	Y
NATIONAL HONOR	36	86.1	Y	N	N
NATIONAL PRIDE	153	11.1	Y	N	N
NAUTICAS MEXICO	86	100.0	N	N	N
NEDLLOYD DELFT	114	100.0	N	N	N
NEDLLOYD HOLLAND	143	78.3	Y	Y	Y
NEDLLOYD MAAS	82	100.0	N	N	N
NEDLLOYD RALEIGH BAY	48	100.0	N	N	N
NEDLLOYD ROTTERDAM	129	100.0	N	N	N
NEDLLOYD VAN CLOON	59	100.0	N	N	N
NEDLLOYD VAN DIEMEN	102	100.0	N	N	N
NEDLLOYD VAN DAJIMA	14	100.0	N	N	N
NEDLLOYD VAN NECK	56	100.0	N	N	N
NEDLLOYD VAN NOORT	92	100.0	N	N	N
NEGO LOMBOK	103	99.0	N	N	N
NELVANA	83	100.0	N	N	N
NEPTUNE ACE	60	100.0	N	N	N
NEPTUNE AKABAR	82	0.0	Y	N	N
NEPTUNE CORAL	30	100.0	N	N	N
NEPTUNE CRYSTAL	9	100.0	N	N	N
NEPTUNE DIAMOND	33	100.0	N	N	N
NEPTUNE GARNET	29	100.0	N	N	N
NEPTUNE JADE	30	100.0	N	N	N
NEPTUNE PEARL	12	100.0	N	N	N
NESLIHAN	1	100.0	N	N	N
NEW CARISSA	17	100.0	N	N	N
NEW NIKKI	168	94.6	Y	Y	Y
NEW VENUS	30	100.0	N	N	N
NEW YORK SENATOR	162	100.0	N	N	N
NEW YORK SUN	58	94.8	Y	Y	N
NEWARK BAY	173	94.2	Y	Y	Y
NEWPORT BRIDGE	57	100.0	N	N	N
NIEUW AMSTERDAM	90	100.0	N	N	N
NOAA DAVID STARR JORDA	26	61.5	Y	Y	Y
NOAA SHIP ALBATROSS IV	103	77.6	Y	Y	Y
NOAA SHIP DISCOVERER O	598	80.7	Y	Y	Y

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NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
NOAA SHIP FERREL	19	100.0	N	N	N
NOAA SHIP MCARTHUR	29	100.0	N	N	N
NOAA SHIP MILLER FREEM	338	67.1	N	N	N
NOAA SHIP OREGON II	241	2.0	Y	Y	Y
NOAA SHIP RAINIER	9	55.5	N	N	N
NOAA SHIP T. CROMWELL	420	100.0	N	N	N
NOAA SHIP WHITING	1	100.0	N	N	N
NOBEL STAR	76	90.7	Y	N	N
NOL AMBER	10	100.0	N	N	N
NOL CANOPUS	29	96.5	Y	N	N
NOL RUBY	47	100.0	N	N	N
NOL TOPAZ	29	100.0	N	N	N
NOMZI	399	77.4	Y	Y	Y
NORD JAHRE TRANSPORTER	136	100.0	N	N	N
NORTHERN LION	252	100.0	N	N	N
NORWAY	152	49.3	Y	Y	Y
NOSAC CEDAR	126	100.0	N	N	N
NOSAC EXPRESS	76	84.2	Y	Y	Y
NOSAC RANGER	132	69.6	N	N	N
NOSAC TAI SHAN	22	77.2	N	N	N
NOSAC TAKARA	13	69.2	N	N	N
NOSAC TAKAYAMA	146	27.3	Y	Y	Y
NOSAC YOHJIN	1	100.0	N	N	N
NUERNBERG EXPRESS	701	100.0	N	N	N
NUEVO LEON	122	68.0	Y	Y	Y
NUKA ARCTICA	256	100.0	N	N	N
NYK SEABREEZE	97	100.0	N	N	N
NYK SPRINGTIDE	122	100.0	N	N	N
NYK STARLIGHT	70	100.0	N	N	N
NYK SUNRISE	95	100.0	N	N	N
NYK SURFWIND	50	100.0	N	N	N
OAXACA	198	100.0	N	N	N
OBO ELIF	27	3.7	Y	Y	N
OCEAN LAUREL	38	100.0	N	N	N
OCEAN ORCHID	34	97.0	Y	N	N
OCEAN SERENE	2	100.0	N	N	N
OCEAN SPIRIT	128	100.0	N	N	N
OCEANBREEZE	76	97.3	Y	Y	Y
ODELIA	17	88.2	Y	N	N
OJI PIONEER	97	43.2	N	N	N
OLAVUR HALGI	214	100.0	N	N	N
OLEANDER	162	79.6	Y	Y	Y
OLIVEBANK	23	100.0	N	N	N
OLYMPIAN HIGHWAY	46	89.1	N	N	N
OMI COLUMBIA	66	98.4	Y	N	N
OOCL AMERICA	76	94.7	Y	Y	Y
OOCL BRAVERY	95	100.0	N	N	N
OOCL CALIFORNIA	45	100.0	N	N	N
OOCL EDUCATOR	12	100.0	N	N	N
OOCL ENVOY	25	100.0	N	N	N
OOCL FAIR	65	93.8	Y	Y	Y
OOCL FAITH	53	100.0	N	N	N
OOCL FIDELITY	107	82.2	Y	Y	Y
OOCL FORTUNE	31	90.3	N	N	N
OOCL FREEDOM	167	100.0	N	N	N
OOCL FRIENDSHIP	47	100.0	N	N	N
OOCL HONG KONG	193	54.4	N	N	N
OOCL INNOVATION	120	61.6	Y	Y	Y
OOCL INSPIRATION	155	85.1	Y	N	N
ORANGE BLOSSOM	69	60.8	Y	N	N
ORCHIS ISLAND	64	14.0	N	N	N
OREGON RAINBOW III	98	53.0	N	N	N
ORIENTAL FERM	1	100.0	N	N	N
ORIENTE NOBLE	110	22.7	N	N	N
ORIENTE PRIME	25	96.0	N	N	N
ORION HIGHWAY	161	62.7	Y	Y	Y
OSAKA BAY	150	100.0	N	N	N
OURO DO BRASIL	48	95.8	Y	Y	Y
OVERSEAS ALASKA	57	50.8	Y	Y	Y
OVERSEAS ARCTIC	91	75.8	Y	Y	Y
OVERSEAS BOSTON	28	96.4	N	N	N
OVERSEAS CHICAGO	23	8.6	Y	N	N
OVERSEAS HARRIET	34	100.0	Y	Y	Y
OVERSEAS JOYCE	101	71.2	N	N	N
OVERSEAS JUNEAU	113	0.0	Y	Y	Y
OVERSEAS MARILYN	93	30.1	Y	N	N
OVERSEAS NEW ORLEANS	50	80.0	Y	Y	Y
OVERSEAS OHIO	47	74.4	Y	Y	Y
OVERSEAS WASHINGTON	57	77.1	N	N	N
PACASIA	113	69.0	N	N	N
PACDUKE	39	100.0	N	N	N
PACIFIC ARIES	4	100.0	N	N	N
PACIFIC HIRO	102	92.1	N	N	N
PACIFIC PRINCESS	108	100.0	N	N	N
PACIFIC WAVE	156	100.0	N	N	N
PACMERCHANT	32	100.0	N	N	N
PACPRINCE	22	100.0	N	N	N
PACPRINCESS	21	100.0	N	N	N
PACSEA	28	100.0	N	N	N
PACSUN	1	100.0	N	N	N
PATRIOT	136	78.6	N	N	N
PATRIOT STATE	22	100.0	N	N	N
PAUL BUCK	153	45.0	Y	Y	Y
PAUL R. TREGURTHA	43	90.6	Y	N	N
PEDER OLSEN	11	100.0	N	N	N
PEGGY DOW	28	100.0	N	N	N
PFC DEWAYNE T. WILLIAM	100	42.0	N	N	N
PFC EUGENE A. OBREGON	18	61.1	Y	Y	N
PFC JAMES ANDERSON JR	1	0.0	Y	N	N
PHAROS	68	100.0	N	N	N
PHILADELPHIA	40	0.0	Y	Y	N
PHILIP R. CLARKE	14	78.5	Y	N	N
PHOENIX DIAMOND	5	100.0	N	N	N
PIONEER SERVICE	8	0.0	Y	N	N
PISCES EXPLORER	28	100.0	N	N	N
PISCES PIONEER	87	100.0	N	N	N
PISCES PLANTER	36	100.0	N	N	N
PLATTE	100	30.0	N	N	N
POLAR EAGLE	157	43.3	Y	Y	Y
POLYNESIA	82	8.5	Y	Y	N
POROS	52	94.2	Y	Y	Y
PORT STAR	76	100.0	N	N	N
POTOMAC	6	100.0	N	N	N
POTOMAC TRADER	50	92.0	N	N	N
POVL ANKER	53	100.0	N	N	N
POYANG	249	100.0	N	N	N
POYARKOVO	49	100.0	N	N	N
PRESIDENT ADAMS	218	58.7	Y	Y	Y
PRESIDENT ARTHUR	75	45.3	Y	N	N
PRESIDENT BUCHANAN	53	15.0	N	N	N
PRESIDENT EISENHOWER	202	75.7	Y	Y	Y
PRESIDENT F. ROOSEVELT	185	80.0	Y	N	N
PRESIDENT HARDING	139	19.4	Y	Y	Y
PRESIDENT JACKSON	173	0.0	Y	Y	Y
PRESIDENT KENNEDY	144	74.3	Y	Y	Y
PRESIDENT POLK	176	88.0	Y	Y	Y
PRESIDENT TRUMAN	93	55.9	Y	Y	N
PRIDE OF BALTIMORE II	2	100.0	N	N	N
PRINCE OF OCEAN	231	44.5	Y	Y	Y
PRINCE OF TOKYO 2	253	43.4	Y	Y	Y
PRINCE OF TOKYO	114	52.6	Y	Y	N
PRINCE WILLIAM SOUND	89	31.4	Y	Y	N
PRINCESS OF SCANDINAVI	141	100.0	N	N	N
PROFESOR MIERZEJEWSKI	1	100.0	N	N	N
PROJECT ORIENT	121	100.0	N	N	N
PUERTO CORTES	91	94.5	Y	N	N
PYTCHLEY	210	100.0	N	N	N
QUEEN ELIZABETH 2	193	100.0	N	N	N

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VOS Cooperative Ship Reports (Continued from Page 74)

NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
QUEEN OF SCANDINAVIA	252	100.0	N	N	N
QUEENSLAND STAR	183	100.0	N	N	N
R.J. PFEIFFER	94	25.5	Y	Y	Y
RANGER	27	100.0	N	N	N
RANI PADMINI	6	100.0	N	N	N
RECIFE	95	100.0	N	N	N
REGAL EMPRESS	48	100.0	N	N	N
REGAL PRINCESS	65	100.0	N	N	N
REPULSE BAY	130	100.0	N	N	N
RESERVE	5	60.0	Y	N	N
RESOLUTE	140	47.8	Y	Y	Y
RHINE FOREST	202	50.0	Y	Y	Y
RICHARD G MATTIESEN	18	66.6	N	N	N
RICHMOND BAY	48	100.0	N	N	N
ROBERT E. LEE	84	77.3	Y	N	N
ROGER BLOUGH	46	84.7	Y	N	N
ROSINA TOPIC	166	40.9	Y	Y	Y
ROSITA	64	92.1	Y	Y	Y
ROTTERDAM	32	100.0	N	N	N
ROYAL MAJESTY	139	1.4	Y	Y	Y
ROYAL PRINCESS	57	100.0	N	N	N
RUBIN BONANZA	82	91.4	Y	Y	Y
RUBIN KOBE	218	94.0	Y	Y	Y
RUBIN ROSE	28	100.0	N	N	N
RUBIN STAR	25	100.0	N	N	N
RUBIN STELLA	159	34.5	Y	Y	Y
RYNDAM	34	100.0	N	N	N
S.T. CRAPO	4	100.0	N	N	N
S/S WILSON	25	36.0	Y	N	N
SALINA CRUZ PILOTS	1	100.0	N	N	N
SALINAS	36	100.0	N	N	N
SALLEQ	22	100.0	N	N	N
SALOME	88	37.5	N	N	N
SAM HOUSTON	54	62.9	Y	N	N
SAMSON	54	100.0	N	N	N
SAMUEL GINN	49	69.3	Y	Y	Y
SAMUEL H. ARMACOST	78	74.3	Y	Y	N
SAMUEL L. COBB	87	100.0	N	N	N
SAMUEL RISLEY	639	100.0	N	N	N
SAN ISIDRO	153	100.0	N	N	N
SAN MARCOS	49	59.1	Y	Y	Y
SAN VINCENTE	46	100.0	N	N	N
SANKO LAUREL	7	100.0	N	N	N
SANKO MOON	43	100.0	N	N	N
SANKO POPPY	171	56.1	Y	Y	Y
SANKO SPRUCE	78	57.6	Y	N	N
SANTA FE DE BOGOTA	10	100.0	N	N	N
SANTORIN 2	267	23.2	N	N	N
SARAJEVO EXPRESS	4	100.0	N	N	N
SARFAQITTUK	26	100.0	N	N	N
SARPIKITTUK	5	100.0	N	N	N
SAUDI RIYADH	10	20.0	Y	Y	N
SAUDI TABUK	23	100.0	N	N	N
SAVANNAH	5	100.0	N	N	N
SCHACKENBORG	8	100.0	N	N	N
SEA COMMERCE	151	43.7	Y	Y	Y
SEA EXCELLENCE	43	93.0	Y	Y	N
SEA FLORIDA	114	74.5	Y	Y	Y
SEA FOX	145	41.3	N	N	N
SEA GUARDIAN	97	37.1	N	N	N
SEA HARMONY	11	100.0	N	N	N
SEA ISLE CITY	34	50.0	Y	N	N
SEA JUSTICE	67	64.1	Y	Y	Y
SEA LION	356	76.6	Y	Y	Y
SEA MARINER	89	100.0	N	N	N
SEA MERCHANT	386	97.6	Y	Y	Y
SEA NOVIA	54	88.8	Y	Y	Y
SEA PREMIER	38	100.0	N	N	N
SEA TRADE	163	93.8	Y	Y	N
SEA WOLF	161	46.5	N	N	N
SEABOARD OCEAN	102	4.9	Y	Y	Y
SEABOARD SUN	44	2.2	Y	Y	Y
SEABOARD UNIVERSE	98	85.7	Y	Y	Y
SEABREEZE I	17	100.0	N	N	N
SEALAND ANCHORAGE	188	52.6	N	N	N
SEALAND ATLANTIC	148	68.2	Y	Y	Y
SEALAND CHALLENGER	140	48.5	Y	Y	Y
SEALAND CHAMPION	187	86.6	Y	Y	Y
SEALAND COMET	200	92.0	Y	Y	Y
SEALAND CONSUMER	35	68.5	Y	N	N
SEALAND COSTA RICA	89	65.1	Y	Y	N
SEALAND CRUSADER	117	97.4	N	N	N
SEALAND DEFENDER	179	64.2	N	N	N
SEALAND DEVELOPER	71	73.2	Y	N	N
SEALAND DISCOVERY	167	44.9	N	N	N
SEALAND ENDURANCE	81	66.6	Y	Y	Y
SEALAND ENTERPRISE	207	80.1	Y	Y	Y
SEALAND EXPEDITION	60	45.0	N	N	N
SEALAND EXPLORER	161	92.5	Y	Y	Y
SEALAND EXPRESS	160	72.5	Y	Y	Y
SEALAND FREEDOM	3	100.0	N	N	N
SEALAND HAWAII	116	92.2	Y	Y	Y
SEALAND INDEPENDENCE	77	36.3	Y	Y	N
SEALAND INNOVATOR	113	61.9	N	N	N
SEALAND INTEGRITY	292	34.9	N	N	N
SEALAND KODIAK	23	100.0	N	N	N
SEALAND LIBERATOR	40	100.0	N	N	N
SEALAND MERCURY	108	100.0	N	N	N
SEALAND METEOR	131	90.8	N	N	N
SEALAND NAVIGATOR	167	75.4	Y	Y	Y
SEALAND PACIFIC	283	83.0	Y	Y	Y
SEALAND PATRIOT	132	47.7	Y	Y	Y
SEALAND PERFORMANCE	142	83.8	Y	Y	Y
SEALAND PRODUCER	90	61.1	Y	Y	Y
SEALAND QUALITY	65	67.6	Y	N	N
SEALAND RACER	32	100.0	N	N	N
SEALAND RELIANCE	226	65.4	Y	Y	Y
SEALAND SPIRIT	126	61.1	Y	Y	Y
SEALAND TACOMA	134	50.0	Y	N	N
SEALAND TRADER	253	81.4	Y	Y	Y
SEALAND VOYAGER	137	56.2	Y	Y	Y
SEARIVER BATON ROUGE	18	77.7	Y	Y	Y
SEARIVER BENICIA	41	87.8	Y	Y	N
SEARIVER CHARLESTOWN	16	100.0	Y	N	N
SEARIVER LONG BEACH	41	85.3	Y	Y	Y
SEARIVER PHILADELPHIA	1	100.0	N	N	N
SEARIVER SAN FRANCISCO	26	30.7	Y	Y	Y
SEDCO/BP 471	326	65.0	N	N	N
SENATOR	120	100.0	N	N	N
SENORITA	148	20.2	Y	Y	Y
SENSATION	113	49.5	Y	Y	Y
SERENITY	161	50.9	Y	Y	Y
SETO BRIDGE	125	100.0	N	N	N
SEVEN OCEAN	36	86.1	Y	Y	Y
SEWARD JOHNSON	249	51.4	Y	Y	Y
SGT WILLIAM A BUTTON	10	100.0	N	N	N
SGT. METEJ KOCAK	57	77.1	Y	Y	Y
SHELDON LYKES	81	54.3	Y	Y	Y
SHELLY BAY	60	76.6	Y	Y	Y
SHIRAOI MARU	202	77.7	Y	Y	Y
SIBOHELLE	29	100.0	N	N	N
SIDNEY STAR	130	100.0	N	N	N
SIETE OCEANO	27	100.0	N	N	N
SINCERE GEMINI	54	98.1	Y	Y	N
SINGAPORE EXPRESS	10	100.0	N	N	N
SISIMIUT	37	100.0	N	N	N
SKAUBRYN	69	100.0	N	N	N
SKAUGRAN	108	100.0	N	N	N

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VOS Cooperative Ship Reports (Continued from Page 75)

NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
SKOGAFOSS	209	100.0	N	N	N
SKY PRINCESS	8	100.0	N	N	N
SOKOLICA	14	100.0	N	N	N
SOL DO BRASIL	146	96.5	Y	Y	Y
SOLANO	66	100.0	N	N	N
SOLAR WING	84	100.0	N	N	N
SONORA	112	72.3	Y	Y	Y
SOREN TOUBRO	53	100.0	N	N	N
SOUTHERN LION	101	100.0	N	N	N
SOUTHERN PRINCESS	159	0.0	Y	Y	Y
SOVEREIGN OF THE SEAS	74	78.3	Y	Y	Y
SP5. ERIC G. GIBSON	26	80.7	Y	Y	N
SPRING BEAR	134	100.0	N	N	N
SPRING GANNET	207	66.6	Y	Y	Y
STAFFORDSHIRE	165	100.0	N	N	N
STAR ALABAMA	42	100.0	N	N	N
STAR AMERICA	58	81.0	N	N	N
STAR DAVANGER	37	100.0	N	N	N
STAR DROTTANGER	2	100.0	N	N	N
STAR EAGLE	16	100.0	N	N	N
STAR EVVIVA	122	74.5	Y	Y	Y
STAR FLORIDA	86	2.3	Y	Y	Y
STAR FRASER	115	100.0	N	N	N
STAR FUJI	41	100.0	N	N	N
STAR GEIRANGER	11	100.0	N	N	N
STAR GRAN	77	45.4	Y	Y	N
STAR HERDLA	13	100.0	N	N	N
STAR SIRANGER	2	100.0	N	N	N
STAR SKARVEN	90	52.2	N	N	N
STAR STRONEN	37	100.0	N	N	N
STATE OF GUIARAT	10	100.0	N	N	N
STELLA	40	100.0	Y	N	N
STEPAN KRASHENINNIKOV	24	100.0	N	N	N
STEWART J. CORT	26	92.3	Y	N	N
STOLT AVENIR	19	47.3	Y	N	N
STOLT CONDOR	25	100.0	N	N	N
STOLT JADE	20	100.0	N	N	N
STOLT RESOLUTE	62	100.0	N	N	N
STONEWALL JACKSON	35	71.4	Y	Y	N
STRONG CAJUN	122	54.9	Y	Y	Y
STRONG VIRGINIAN	8	100.0	N	N	N
SUNBELT DIXIE	42	100.0	N	N	N
SUNDA	83	100.0	N	N	N
SUPER RUBIN	60	31.6	N	N	N
SVEN OLTMANN	141	97.1	Y	Y	N
TAI HE	127	100.0	N	N	N
TAI SHING	13	100.0	N	N	N
TALLAHASSEE BAY	18	100.0	N	N	N
TAMPA	23	100.0	N	N	N
TAMPA BAY	18	100.0	N	N	N
TEPOZTECO II	112	100.0	N	N	N
TEQUI	191	89.5	Y	Y	Y
THOMAS G. THOMPSON	99	49.4	Y	Y	N
THOMPSON LYKES	72	43.0	Y	Y	N
TILLIE LYKES	107	56.0	N	N	N
TIMIARMIUT	67	100.0	N	N	N
TJALDRID	127	100.0	N	N	N
TOKIO EXPRESS	95	100.0	N	N	N
TOLUCA	85	100.0	N	N	N
TONSINA	41	80.4	N	N	N
TOR DANIA	377	100.0	N	N	N
TORBEN	347	36.5	Y	Y	Y
TORM FREYA	65	40.0	Y	Y	N
TOWER BRIDGE	48	100.0	N	N	N
TRANSWORLD BRIDGE	190	86.8	Y	Y	Y
TRIGGER	44	93.1	N	N	N
TRITON	13	0.0	Y	N	N
TROPIC DAY	48	64.5	Y	Y	Y
TROPIC FLYER	25	0.0	Y	Y	N
TROPIC ISLE	230	0.0	Y	Y	Y
TROPIC JADE	58	41.3	Y	Y	Y
TROPIC KEY	17	5.8	Y	N	N
TROPIC LURE	61	11.4	Y	Y	Y
TROPIC MIST	51	0.0	Y	Y	Y
TROPIC PALM	23	0.0	N	N	N
TROPIC SUN	103	0.0	Y	Y	Y
TROPIC TIDE	84	84.5	Y	Y	Y
TRSL ARCTURUS	97	100.0	N	N	N
TRUST 38	125	36.8	Y	Y	N
TULSIDAS	18	100.0	N	N	N
TULUGAQ	39	100.0	N	N	N
TYSON LYKES	118	39.8	Y	Y	Y
ULLSWATER	155	100.0	N	N	N
USCGC ACACIA (WLB406)	32	84.3	N	N	N
USCGC ACTIVE WMEC 618	186	35.4	N	N	N
USCGC ACUSHNET WMEC 16	103	100.0	N	N	N
USCGC ALERT (WMEC 630)	13	100.0	N	N	N
USCGC BASSWOOD (WLB 38	27	100.0	N	N	N
USCGC BEAR (WEMC 901)	16	100.0	N	N	N
USCGC BOUTWELL WHEC 71	45	100.0	N	N	N
USCGC CAMPBELL	86	63.9	Y	N	N
USCGC CHASE (WHEC 718)	159	84.2	Y	Y	Y
USCGC CONFIDENCE WMEC6	12	100.0	N	N	N
USCGC COURAGEOUS	18	100.0	N	N	N
USCGC DAUNTLESS WMEC 6	70	100.0	N	N	N
USCGC DECISIVE WMEC 62	38	100.0	N	N	N
USCGC DILIGENCE WMEC 6	17	100.0	N	N	N
USCGC DURABLE (WMEC 62	68	100.0	N	N	N
USCGC FIREBUSH WLB 393	30	100.0	N	N	N
USCGC FORWARD	15	100.0	N	N	N
USCGC GALLATIN	13	100.0	N	N	N
USCGC HARRIET LANE	21	90.4	Y	Y	Y
USCGC JARVIS (WHEC 725	121	100.0	N	N	N
USCGC LEGARE	45	84.4	Y	Y	Y
USCGC MACKINAW	19	73.6	Y	N	N
USCGC MELLON (WHEC 717	152	100.0	N	N	N
USCGC MIDGETT (WHEC 72	38	97.3	N	N	N
USCGC MOHAWK WMEC 913	10	100.0	N	N	N
USCGC MORGENTHAU	4	100.0	N	N	N
USCGC MUNRO	38	86.8	N	N	N
USCGC NORTHLAND WMEC 9	38	97.3	N	N	N
USCGC POLAR STAR (WAGB	150	100.0	N	N	N
USCGC RELIANCE WMEC 61	70	100.0	N	N	N
USCGC RUSH	159	100.0	N	N	N
USCGC SASSAFRAS	9	100.0	N	N	N
USCGC SEDGE (WLB 402)	18	100.0	N	N	N
USCGC SENECA	93	100.0	N	N	N
USCGC SHERMAN	145	88.2	Y	Y	Y
USCGC SPENCER	17	100.0	N	N	N
USCGC STEADFAST (WMEC	105	53.3	N	N	N
USCGC STORIS (WMEC 38)	215	76.7	Y	N	N
USCGC SUNDEW (WLB 404)	15	73.3	Y	N	N
USCGC SWEETBRIER WLB 4	53	100.0	N	N	N
USCGC TAHOMA	43	100.0	N	N	N
USCGC TAMPA WMEC 902	31	0.0	N	N	N
USCGC THETIS	23	0.0	Y	Y	N
USCGC VALIANT (WMEC 62	92	86.9	Y	Y	Y
USCGC VIGILANT WMEC 61	6	100.0	N	N	N
USCGC VIGOROUS WMEC 62	65	66.1	Y	Y	N
USCGC WOODRUSH (WLB 40	52	100.0	N	N	N
USCGC YOCONA (WMEC 168	38	76.3	Y	Y	Y
USNS ALGOL	20	100.0	N	N	N
USNS ANTARES	12	8.3	N	N	N
USNS APACHE (T-ATF 172	20	100.0	N	N	N
USNS BIGHORN	143	0.0	Y	Y	Y
USNS CAPELLA	10	0.0	Y	N	N
USNS GUADALUPE	7	100.0	N	N	N
USNS GUS W. DARNELL	173	57.2	Y	Y	Y

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VOS Cooperative Ship Reports (Continued from Page 76)

NAME	TOTAL OBS	PERCENT VIA RADIO	MANUSCRIPT RECEIVED JAN	FEB	MAR
USNS HAYES	45	0.0	N	N	N
USNS HENRY J. KAISER	5	100.0	N	N	N
USNS JOHN LENTHALL	110	0.0	Y	Y	N
USNS JOHN MCDONNELL (T	37	0.0	N	N	N
USNS KANE TAGS 27	56	80.3	Y	Y	N
USNS LITTLEHALES (T-AG	1	100.0	N	N	N
USNS MOHAWK (T-ATF 170	70	30.0	Y	N	N
USNS NARRAGANSETT	58	96.5	Y	N	N
USNS NAVAJO_(TATF-169)	10	100.0	N	N	N
USNS OBSERVATION ISLAN	19	100.0	N	N	N
USNS PATHFINDER T-AGS	35	62.8	Y	N	N
USNS PECOS	107	100.0	N	N	N
USNS POWHATAN TATF 166	107	100.0	N	N	N
USNS REGULUS	36	100.0	N	N	N
USNS SAN DIEGO	58	100.0	N	N	N
USNS SILAS BENT T-AGS	48	100.0	N	N	N
USNS TIPPECANOE (TAO-1	83	87.9	N	N	N
USNS VANGUARD TAG 194	9	100.0	N	N	N
USNS WALTER S. DIEHL	7	100.0	N	N	N
USNS WYMAN (T-AGS 34)	171	100.0	N	N	N
USS RUSSELL DDG-59	73	100.0	N	N	N
VAEDDEREN	224	100.0	N	N	N
VAN TRADER	41	90.2	N	N	N
VEGA	13	100.0	N	N	N
VENUS DIAMOND	29	100.0	N	N	N
VERA ACORDE	17	100.0	N	N	N
VIDAL	64	100.0	N	N	N
VINE	197	100.0	N	N	N
VIRGINIA	331	12.3	Y	Y	Y
VISAYAS VICTORY	61	0.0	Y	Y	Y
VIVA	171	28.6	Y	Y	Y
WADI SUDR	33	0.0	N	N	N
WALTER J. MCCARTHY	16	62.5	Y	N	N
WESTERDAM	57	100.0	N	N	N
WESTERN FRIEND	52	53.8	N	N	N
WESTERN LION	31	100.0	N	N	N
WESTWARD	2	100.0	N	N	N
WESTWARD VENTURE	386	80.0	Y	Y	Y
WESTWOOD ANETTE	197	80.7	Y	Y	Y
WESTWOOD BELINDA	108	65.7	Y	N	N
WESTWOOD CLEO	117	100.0	N	N	N
WESTWOOD FUJI	51	82.3	Y	Y	Y
WESTWOOD HALLA	162	83.3	Y	Y	Y
WESTWOOD JAGO	84	70.2	Y	Y	N
WESTWOOD MARIANNE	153	77.7	Y	Y	Y
WILFRED SYKES	24	58.3	Y	N	N
WILLAMETTE	36	52.7	Y	N	N
WILLIAM E. MUSSMAN	92	41.3	Y	Y	Y
WOLVERINE	1	100.0	Y	N	N
YOUNG SPROUT	31	0.0	Y	Y	Y
YUCATAN	94	17.0	Y	Y	Y
YURIY OSTROVSKIY	135	89.6	Y	Y	Y
YUYO BREEZE	28	82.1	Y	Y	Y
ZAGREB EXPRESS	24	100.0	N	N	N
ZENITH	35	100.0	N	N	N
ZETLAND	188	100.0	N	N	N
ZIM AMERICA	131	100.0	N	N	N
ZIM CANADA	55	100.0	N	N	N
ZIM IBERIA	28	100.0	N	N	N
ZIM ISRAEL	84	100.0	N	N	N
ZIM ITALIA	117	82.9	Y	Y	N
ZIM JAPAN	96	100.0	N	N	N
ZIM KEELUNG	101	100.0	N	N	N
ZIM KOREA	49	100.0	N	N	N
ZIM MONTEVIDEO	9	100.0	N	N	N
ZIM PARAGUAY	91	59.3	N	N	N
GRAND TOTAL	99142				
TOTAL VIA RADIO	76581				
PERCENT VIA RADIO		77.2			

Buoy Climatological Data Summary

Weather observations are taken each hour during a 20-minute averaging period, with a sample taken every 0.67 seconds. The significant wave height is defined as the average height of the highest one-third of the waves during the average period each hour. The maximum significant wave height is the highest of those values for that month. At most stations, air temperature, water temperature, wind speed and direction are sampled once per second during an 8.0-minute averaging period each hour (moored buoys) and a 2.0-minute averaging period for fixed stations (C-MAN). Contact NDBC Data Systems Division, Bldg. 1100, SSC. Mississippi 39529 or phone (601) 688-1720 for more details.

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SCALAR WAVE HT (DA/HR)	MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KNOTS)	MAX WIND (DA/HR)	MEAN PRESS (MB)
41001	34.7N	072.6W	0259	15.0	20.1	2.4	4.4	29/09	16.9	S	31.9	29/02	1019.6
41002	32.4N	075.3W	0737	16.1	22.2				17.5	SW	33.8	12/11	1016.4
41004	32.5N	079.1W	0743	13.6	16.7	1.6	4.8	11/11	15.0	SW	32.8	11/08	1018.0
41006	29.3N	077.3W	0737	19.3	21.8	2.3	9.9	11/20	17.1	S	40.0	11/12	1016.3
41009	28.5N	080.2W	1485	18.2	19.9	1.5	6.9	11/13	15.3	NW	38.3	11/14	1017.5
41010	28.9N	078.5W	1483	19.4	22.3	2.3	9.9	11/10	16.2	S	38.3	11/22	1017.0
41021	31.9N	080.9W	0317	12.6	13.4	0.7	1.8	28/00	12.1	NE	30.7	19/14	1016.2
41022	31.9N	080.9W	0317	12.7	13.3	0.7	2.0	28/03	12.2	NE	30.7	19/15	1016.0
41023	31.9N	080.9W	0224	14.0	14.1	0.3	1.0	28/05	9.5	NE	28.6	28/00	1019.5
42002	25.9N	093.6W	0574	19.1	22.2	1.9	5.4	07/21	16.3	SE	35.0	07/15	1017.5
42003	25.9N	085.9W	0732	21.2	25.2	1.8	5.3	21/03	17.4	S	37.7	21/00	1016.4
42007	30.1N	088.8W	0742	13.5	15.8				13.9	SE	43.5	19/04	1017.9
42019	27.9N	095.0W	0744	16.9	20.1	1.5	4.7	07/14	13.6	SE	32.1	07/11	1017.0
42020	27.0N	096.5W	0739	17.6		1.6	5.6	07/13	14.0	SE	35.6	07/09	1016.9
42035	29.3N	094.4W	0740	13.8	15.3	0.9	2.9	26/17	11.7	SE	33.2	07/11	1017.3

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Buoy Climatological Data Summary (Continued from Page 77)

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SCALAR WAVE HT (DA/HR)	MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KNOTS)	MAX WIND (DA/HR)	MEAN PRESS (MB)
42036	28.5N	084.5W	0419	15.5	17.7	1.3	3.9	11/10	13.2	N	31.9	11/13	1020.0
42039	28.8N	086.0W	0742	16.9	19.8	1.4	6.0	19/11	13.5	SE	33.4	19/08	1017.4
42040	29.2N	088.3W	0740	15.9	19.0	1.4	4.5	19/06	13.3	SE	34.2	19/02	1017.1
44004	38.5N	070.7W	0736	8.7	13.1	2.6	6.1	12/17	16.7	NW	35.8	29/21	1016.0
44005	42.9N	069.0W	0740	1.3	3.1	1.7	5.1	04/03	14.8	NW	38.9	04/02	1013.7
44007	43.5N	070.2W	0743	0.1	2.8	0.9	3.8	20/13	15.6	N	28.8	04/03	1013.9
44009	38.5N	074.7W	0739	3.4	4.0	1.4	4.4	29/16	13.5	S	32.1	03/21	1016.3
44011	41.1N	066.6W	0144	2.8	4.6	3.2	6.4	04/06	17.9	W	33.8	04/00	1015.3
44013	42.4N	070.7W	0718	1.3	2.6	0.9	4.0	08/04	12.7	W	31.7	04/00	1014.7
44014	36.6N	074.8W	0714	6.7	7.4	1.8	5.3	12/12	15.1	N	29.9	19/23	1016.8
44025	40.3N	073.2W	0738	2.2	3.0	1.5	4.6	20/04	13.7	W	36.1	20/01	1015.9
44028	41.4N	071.1W	0736		1.7	0.9	3.3	03/21	13.9	SW	39.1	03/20	1015.5
45007	42.7N	087.0W	0097	1.4	1.1	0.6	2.6	31/21	11.4	NE	25.1	31/19	1019.5
46001	56.3N	148.2W	0739	2.9	3.7	2.5	5.7	08/21	11.8	SW	31.1	08/19	1017.3
46002	42.5N	130.3W	0742	9.7	10.6	2.7	6.1	19/16	11.9	SE	28.4	05/03	1017.2
46003	51.9N	155.9W	0743	3.4	4.0	3.1	6.7	09/07	11.7	E	25.5	15/01	1015.0
46005	46.1N	131.0W	0688	8.2	9.0	2.7	7.8	19/16	13.4	SW	28.8	19/05	1018.0
46006	40.9N	137.5W	0738	11.2	11.5	3.2	6.7	24/17	13.6	S	35.0	01/13	1014.6
46012	37.4N	122.7W	0742	12.3	12.7	2.0	5.5	13/06	9.8	NW	25.6	23/12	1016.6
46013	38.2N	123.3W	0743	12.0	12.6	2.2	5.3	13/03	13.2	NW	30.7	13/11	1017.9
46014	39.2N	124.0W	0744	11.5	11.8	2.4	5.8	20/09	12.0	NW	32.1	13/01	1016.9
46022	40.8N	124.5W	0738	11.2	11.4	2.4	5.9	13/07	13.3	N	35.2	13/01	1018.7
46023	34.3N	120.7W	0719	13.3	14.4	2.2	5.4	13/14	13.0	NW	30.9	23/08	1017.0
46025	33.8N	119.1W	0732	13.6	14.1	1.2	3.4	13/18	7.4	W	26.6	29/04	1016.0
46026	37.8N	122.8W	0145	10.9	11.6	1.4	2.6	29/03	9.8	NW	22.3	28/13	1016.1
46027	41.9N	124.4W	0737	10.4	10.8	2.1	4.6	05/17	11.2	NW	35.0	13/00	1017.1
46028	35.7N	121.9W	0736	12.8	13.4	2.3	6.3	13/11	10.7	NW	24.7	22/09	1018.2
46030	40.4N	124.5W	0738	10.9	10.8	2.3	5.3	13/07	13.8	N	33.2	12/23	1018.0
46035	57.0N	177.7W	0731	1.2	1.7	3.4	7.3	12/16	19.6	E	40.0	24/03	
46041	47.4N	124.5W	0740	9.3	9.7	1.8	5.2	19/22	9.5	SE	22.9	31/21	1017.5
46042	36.8N	122.4W	0738	14.2	13.0	2.2	6.5	13/09	10.3	NW	23.9	13/09	1017.5
46045	33.8N	118.5W	0736	13.7	14.3	1.0	2.6	13/07	6.6	NW	22.0	24/00	1015.9
46050	44.6N	124.5W	0740		10.9	2.2	6.1	20/08	10.5	N	25.6	25/13	1018.0
46051	34.5N	120.7W	0741		13.7	2.1	6.9	13/14	11.2	NW	28.0	23/06	1016.9
46053	34.2N	119.9W	0735	13.1	13.2	1.2	3.4	13/14	8.8	W	30.3	23/03	1016.2
46054	34.3N	120.5W	0741	13.1	13.6	2.0	5.2	13/16	13.9	NW	32.8	23/06	1016.7
46059	38.0N	130.0W	0740	12.9	14.0	2.7	5.6	04/18	13.4	N	31.3	04/18	1019.1
46060	60.6N	146.8W	1478	2.4	3.9	0.7	1.8	16/07	9.7	E	31.7	05/06	1017.6
46061	60.2N	146.8W	1470	2.9	3.7	1.5	5.4	13/05	12.0	N	40.4	19/16	1017.5
51001	23.4N	162.3W	0016	21.0	23.1	3.0	3.1	01/05	15.5	E	18.1	01/10	1016.7
51002	17.2N	157.8W	0744	24.2	25.1	2.3	4.3	16/15	14.4	NE	25.1	03/15	1013.7
51003	19.1N	160.8W	0743	23.5	24.9	2.5	4.0	04/08	12.9	NE	26.7	04/09	1014.8
51004	17.4N	152.5W	0737	24.0	25.2	2.4	4.5	26/23	13.7	NE	26.0	04/16	1015.1
51026	21.4N	156.9W	0738	22.1	23.6	2.4	5.0	23/01					1016.4
91204	9.9N	139.7E	0653	27.6					14.9	NE	25.2	28/15	1009.9
91222	18.1N	145.8E	0234	25.7					5.2	E	15.5	01/02	1013.8
91251	11.4N	162.4E	0742	27.3					16.7	NE	26.6	28/09	1009.4
91328	8.6N	149.7E	0741	27.4					9.1	NE	18.8	19/17	1010.9
91338	5.3N	153.7E	0573	28.1					5.8	NE	23.3	22/02	1008.0
91343	7.6N	155.2E	0740	27.8					12.6	NE	27.6	25/18	1008.1
91352	6.2N	160.7E	0743	28.0					11.1	NE	23.1	18/16	1008.8
91355	5.4N	163.0E	0741	27.8					8.1	NE	23.0	04/03	1007.4
91377	6.1N	172.1E	0531	28.0					11.0	NE	36.9	09/06	1011.1
91411	8.3N	137.5E	0579	27.8									1009.1
ABAN6	44.3N	075.9W	0739	-2.7	0.3				5.1	N	24.4	25/19	1017.0
ALSN6	40.5N	073.8W	0742	2.4	3.5	1.0	4.3	30/00	16.9	W	54.0	20/01	1016.4
BLIA2	60.8N	146.9W	1478	1.7					13.1	N	46.0	05/07	1019.2
BURL1	28.9N	089.4W	0739	14.6					14.2	SE	39.4	19/02	1019.1
BUSL1	27.9N	090.9W	0689	18.4					13.9	S	36.5	19/03	1017.4
CARO3	43.3N	124.4W	0741	9.7					10.4	N	37.6	22/06	1017.8
CDRF1	29.1N	083.0W	0742	14.1					9.7	S	24.2	20/21	1018.5
CHLV2	36.9N	075.7W	0743	5.6	5.2	1.2	3.0	12/16	17.1	N	38.9	20/01	1017.5
CLKN7	34.6N	076.5W	0740	9.9					14.6	SW	33.1	11/22	1017.5
DBLN6	42.5N	079.4W	0742	-2.1					11.7	NE	45.0	26/02	1016.7
DESW1	47.7N	124.5W	0739	8.2					10.6	SE	28.0	31/21	1017.8
DISW3	47.1N	090.7W	0739	-4.6					11.7	NE	35.1	25/11	1018.9
DPIA1	30.3N	088.1W	0740	13.3					12.4	SE	39.0	19/05	1018.6
DRYF1	24.6N	082.9W	0741	20.5	20.9				13.7	E	30.9	31/05	1017.4
DSLN7	35.2N	075.3W	0739	10.1		1.8	5.1	12/05	22.7	N	49.6	19/22	1016.5
FBIS1	32.7N	079.9W	0736	11.2					9.9	SW	28.4	27/21	1017.9
FFIA2	57.3N	133.6W	0741	4.2					15.2	N	38.0	20/11	1018.5
FWYF1	25.6N	080.1W	0738	20.6	22.3				16.1	S	33.2	12/03	1017.8
GDIL1	29.3N	090.0W	0741	14.6	16.3				12.0	N	40.2	19/02	1018.7
IOSN3	43.0N	070.6W	0716	0.5					14.3	W	34.7	20/08	1014.6
KTNF1	29.8N	083.6W	0740	13.0					9.9	S	33.9	19/12	1018.2
LKWF1	26.6N	080.0W	0268	18.9	21.8				15.0	NW	26.2	04/17	1018.2
LONF1	24.9N	080.9W	0740	20.6	21.8				13.2	SE	30.9	19/13	
MDRM1	44.0N	068.1W	0742	0.2					14.9	NW	25.1	31/03	1013.4
MISM1	43.8N	068.9W	0741	-0.2					16.0	W	45.5	20/12	1014.1
MLRF1	25.0N	080.4W	0743	20.9	22.2				14.5	SE	29.7	05/06	1017.5
NWPO3	44.6N	124.1W	0742	9.3					8.6	E	30.7	31/22	1017.8
PILM4	48.2N	088.4W	0740	-6.7					12.6	N	34.1	25/19	1018.5
POTA2	61.1N	146.7W	1433	0.9					18.3	N	40.2	05/12	1017.6
PTAC1	39.0N	123.7W	0740	11.2					10.7	N	31.0	13/14	1017.5

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Buoy Climatological Data Summary (Continued from Page 78)

BUOY	LAT	LONG	OBS	MEAN AIR TP (C)	MEAN SEA TP (C)	MEAN SIG WAVE HT (M)	MAX SIG WAVE HT (M)	MAX SCALAR WAVE HT (DA/HR)	MEAN WIND SPEED (KNOTS)	PREV WIND (DIR)	MAX WIND (KNOTS)	MAX WIND (DA/HR)	MEAN PRESS (MB)
PTAT2	27.8N	097.1W	0742	14.6					12.2	SE	32.4	07/09	1017.6
ROAM4	47.9N	089.3W	0739	-6.2					14.5	NE	40.9	25/13	1018.1
SANF1	24.5N	081.9W	0740	20.8	21.5				15.4	N	33.7	09/04	1016.9
SAUF1	29.9N	081.3W	0740	14.4	15.2				9.2	W	25.7	31/02	1018.5
SBIO1	41.6N	082.8W	0582	-2.3					13.5	NE	43.1	25/22	1018.2
SISW1	48.3N	122.9W	0741	7.5					9.2	SE	42.4	15/10	1018.1
SMKF1	24.6N	081.1W	0602	21.3	22.0				16.1	SE	31.7	04/15	1017.8
SPGF1	26.7N	079.0W	0740	20.7	23.3				9.8	E	31.8	12/00	1017.9
SRST2	29.7N	094.1W	0741	13.0					10.5	SE	30.6	18/21	1018.3
STDM4	47.2N	087.2W	0740	-5.9					16.3	NW	43.0	25/14	1018.9
SVLS1	32.0N	080.7W	0738	11.5	12.3	0.9	2.7	11/13	14.9	S	35.9	11/11	1018.0
THIN6	44.3N	076.0W	0740	-2.8									
TPLM2	38.9N	076.4W	0737	4.0	3.9				12.1	NW	34.9	19/20	1017.5
TTIW1	48.4N	124.7W	0741	7.6					12.9	E	37.6	18/14	1017.8
VENF1	27.1N	082.5W	0742	16.5	18.4				11.0	N	29.8	20/23	1018.6
WPOW1	47.7N	122.4W	0738	8.0					8.6	S	24.3	19/10	1018.7

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